America's First Aeronautical Magazine

AVIATION

JUNE 1947

50 CENTS PER COPY

AN IMPORTANT ANNOUNCEMENT TO OUR READERS

See Pages 5, 6 and 7

UNDERWING FUELING'S DESIGN DEVELOPMENT

How new system was built to speed service and make it safer.

★

STANDARDIZING JET NOMENCLATURE

Dr. Fritz Zwicky presents method for eliminating needless confusion of terms in new and growing aeronautical art.

★

NAVY'S SUPER V-2

Engineering behind new Martin-built rocket slated to research million-foot altitudes.

A McGRAW-HILL PUBLICATION

AVIATION

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Aviation Research—Engineering—Production

To Our Readers

Beginning July 7, Aviation will come to you in an entirely new form—a form certain to prove vastly more efficient in helping you design, build, operate, and maintain more efficient aircraft.

It will continue to bring you the prime technical information which established and has maintained Aviation as America's *first* aeronautical magazine, and it will bring you that information with these two important *plus* factors.

First, you will get your technical information *plus* complete but concise analysis and interpretation of the industry's outstanding news—the events which have such vital influence on all phases of research, engineering, production, operation, and maintenance.

Second *plus*—reflecting the very essense of aviation—will be *quadrupled* speed. For in the new form Aviation's information will reach you weekly. From all over the world, technical advances, directly with the news they generate, will come to you every seven days—through use of new high-speed printing equipment, long on order and now ready for service.

To make possible this great publishing stride, the McGraw-Hill Publishing Co. is throwing all its vast resources behind a completely unique American aeronautical journalism service, which will be called AVIATION WEEK.

It will bring together the largest editorial staff ever known in aviation publishing. To Aviation's staff will be added the seasoned, swift-moving news gathering organization of our companion publication, *Aviation News*. This headquarters staff of specialists will be backed by 7 McGraw-Hill News Bureaus, augmented by special correspondents in 41 U. S. cities to give you the most thorough American technical-news coverage ever developed in aeronautical publishing. Unmatched coverage of important foreign technical and news developments will be made possible by McGraw-Hill World News, the company's own fast-growing corps of industrial reporters, with news bureaus in 10 foreign capitals and correspondents in 100 other cities around the globe.

Working through AVIATION WEEK, this powerful organization is dedicated to one single purpose:

TO HELP ADVANCE THE SCIENCE OF AVIATION BY GIVING YOU COMPLETE, AUTHORITATIVE TECHNICAL INFORMATION AND NEWS WITH THE GREATEST POSSIBLE SPEED.

—John Foster, Jr.

An important announcement to every man in the business of aviation...

McGraw-Hill announces a new magazine . . . to bring you, for the first time, the story of both the technical and the news developments that together make up aviation progress . . . in their entirety, week by week

EVERYTHING THAT HAPPENS in aviation happens fast.

Speed is vital to every phase of aviation development—to engineering as well as to operation, to production or maintenance, to design or distribution . . . in military, private and commercial aviation alike. Aeronautical intelligence must be relayed rapidly—interpreted accurately and swiftly—so that you may act upon it right now.

To meet today's need for fast communication of the continuing story of aviation's technological advancements as well as its important headline news—to present both technical and non-technical news developments in correct relationship in one compact, complete, timely magazine . . .

McGraw-Hill begins publication Monday, July 7th, of AVIATION WEEK

AVIATION WEEK is a new concept in aviation journalism.

It is built upon the authoritative technical base of *Aviation and* upon the successful news base of *Aviation News*.

It will tie together the research, design, engineering and production content of *Aviation* with the high-interest news presentation of *Aviation News* . . . and deliver them in one compact editorial package to your desk every week.

But AVIATION WEEK is far more than a simple combination of *Aviation* and *Aviation News*. It is a *new* magazine from cover to cover, incorporating invaluable new features and departments. It is styled for easier, faster reading. You'll find it more compact than any aviation magazine you now read. New high-speed presses and faster mailing equipment will make possible the fastest production schedule ever attempted in aeronautical publishing—speeding the week's news through the mail to you within 24 hours after press closing.

More technical editorial content than you now get in Aviation

Through fast weekly timing, expanded staff facilities, brisk, informative, technical reporting and analysis, more compact type, AVIATION WEEK will deliver to you more *extensive* and more *intensive* coverage of technical developments than now possible in any monthly publication.

Broader news coverage than you now get in Aviation News

Broader staff coverage of all developments, more pictures and an extremely fast production schedule will enable AVIATION WEEK to give you even better and more up-to-the minute news coverage than you now get in *Aviation News*.

Plus such important new editorial features as . . .

"The Aviation Week"—a briefed perspective of the entire aviation picture of the week, designed especially for busy readers. "Aviation World News"—made possible through the world-wide news facilities of the McGraw-Hill International Corporation. "Aviation Index"—a factual, statistical report on current aviation progress in military, commercial and private aviation.

Largest, most experienced editorial staff in aviation publishing

To produce a magazine of the scope and speed of AVIATION WEEK requires an adequate and thoroughly experienced editorial staff. AVIATION WEEK will be manned by the combined staffs of *Aviation* and *Aviation News*, the largest group of editorial specialists of any aviation publication. At their disposal will be the services of the McGraw-Hill Economics Staff, the 14 McGraw-Hill Domestic and Foreign News Bureaus and more than 100 correspondents in every important news center of the world.

Aviation Week is edited for you

If you are in the business of aviation or any of its allied interests, AVIATION WEEK is edited for *you*. You may be engaged in military, transport or private aviation. You may make, use, sell or service airplanes. You may operate an airport or an aviation school. Your interest may be financial, legal or governmental. You may be purchaser or vendor. Whatever your interest, *Aviation Week* is designed to keep you fully abreast of every important business and technical development in aviation.

AVIATION WEEK is a long forward stride in modern aviation journalism. It is born of the longest record of publishing experience in the aviation field. We propose to make it the finest magazine in aviation history.

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- *Present subscribers to Aviation and Aviation News will receive service on the new AVIATION WEEK for the same number of months called for by their original subscriptions.*
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Aviation Week

AVIATION WEEK

INCORPORATING AVIATION AND AVIATION NEWS • A McGRAW HILL PUBLICATION

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What's New

In Products and Practices

. . . Key facts on the latest devices and equipment, tools and materials, product-and-practice literature For additional data on any item, or copies of literature, simply fill in handy form (page 17), clip it to your letterhead and mail to AVIATION Reader's Service. There is no cost, no obligation

Sheet Metal Fastener 1

Previously supplied with aluminum or steel grommet to hold stud sheet metal fastener made by **Lion Fastener, Inc.**, Honeoye Falls N Y, is now available with rubber grommet if desired New grommet, especially adaptable

where air or water seal is required, is applied without special tools allowing quick replacement of one-piece forged stud for longer or shorter unit Fastener has cantilever spring locking unit, is engaged with quarter turn of head, and cadmium finish is reported to resist corrosion for 250 hr in 20% salt spray test.

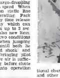
Parachutes and Accessories 2

Irving Air Chute Co., Buffalo, N. Y., announce new features in line of parachutes and accessories. Photo shows Quilter automatic time release to provide delay in opening of cargo-dropping chutes when used at high speed When load is dropped pull on static line starts timing device operating Pack is automatically opened by time release after predetermined delay which can be set at ½-sec intervals up to 3 sec Irvin automatic opener also new item is designed to overcome two conditions —slowing down of pilot when jumping from high speed craft until both he and chute can withstand shock and in high altitude flight bringing pilot down to safe height where air is sufficiently heavy for breathing before chute opens. Opener comes into operation

automatically instant pilot is free of aircraft and opens chute at predetermined altitude without effort on part of pilot. For jumping at low altitude timing device operates so that pilot would decelerate to proper speed before opening to protect pilot and chute from undue shock Opener is placed between rip cord housing and rip cord handle Rip cord itself is not connected to opening device, and handle can be pulled, if necessary, whether or not device is operating Complete device consists of adjustable altimeter, timing device and rip cord opening spring and tunnel Company also announces soft back side-pull chute for those who wear chute at all times when flying Another type is quick attachable soft back, side-pull chute designed for those who desire chute instantly available but do not want to keep chute on at all times Normally harness is kept on with chute placed against back of seat In emergency chute is attached by connecting two risers over shoulder and the snap and V ring around waist

Avigation Tape 3

Including center line to show pilot's course and cross lines to indicate miles flown, avigation aid made by **Grimes Mfg Co.**, Urbana, Ohio is ½-in transparent tape applied to aeronautical charts for course plotting, eliminating need for straight edge and scale Tape is available in two types, one for sec-



tional charts with scale of 1 to 500 000, and other for world charts with scale of 1 to 1 000 000 Once applied tape is not removable, and strengthens chart One sectional chart roll plots 2,000 mi. and one world chart roll, 4,000 mi

Periscopic Sextant 4

Permitting avigator to make observations for plotting position from within cabin, new periscopic sextant is made by **Kollsman Instrument Div, Square D Co.**, Elmhurst New York, to eliminate use of plastic astrodome for taking astronomical sights. Portion of peri-

scope, slightly over 1 in dia., and 1¾ in long, is exposed through craft skin. Specially designed mount has

rotatable section permitting free movement up to 15 deg from zenith Sealing between rotatable section and stationary mount is designed to withstand differential pressure of 15 psi Unit is removed from mount and stored in plane when not in use

Portable Radio 5

Created for personal planes and covering three bands, new portable radio made by **Bendix Radio Div., Bendix Aviation Corp.**, Baltimore, Md provides weather reports, air and marine communications reception, reg-

ular broadcasts, and can be used as aid when avigating on aviation range stations marine radio beacons and broadcast stations Two loop antennas are included inside case for reception and direction finding and an external antenna connector is also provided Set is powered by a self-contained 150-hr A-B battery pack, but may also be plugged into 110v a.c.-d.c outlet Dynamic speaker is built in but for use on weak signals headphone may be plugged in Bands covered are 185 to 410, 540 to 1620 and 2 000 to 5 800 kc. Range filter is built in for 185 to 410 kc band Off-on switch in cover latch shuts receiver off when cover is closed, even though main switch is in on position Size is 6¾ × 11 × 12¾ in and weight is 8 lb

Rate Gyro 6

An angular rate measuring device for application where measurement for control purposes is required, new d.c rate gyro made by **Fairchild Camera and Instrument Corp**, Jamaica, N. Y., has applications including guided missile control (angular rate measuring for control of flight, obtaining information for telemetering purposes), stabilization systems, military and industrial (gun turrets, camera mounts, automatic pilots speed control for large factory machines), computing systems (providing angular velocity parameter for complex physical problems), and certain types of angular velocity indicators and accelerometers Features of unit are take-off element of a.c. reluctance type operating at 115v., 400 cycles, with an output sensitivity of 0 49v per angular deg per sec., and

motor element of d c. governor controlled shunt type operating on range of 24 to 32v d c Motor speed is said to be governor controlled to ± 1% over ambient temperature range of −65 to +160 deg F to maintain accuracy of precession Operating input currents are 0 3 amp d c and 0.02 amp a.c Gyro precession is limited to one plane of freedom and is restrained by a balanced rate spring system.

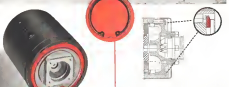
Motor-Operated Shut-Off Valve . . . 7

Developed to replace plug-type shut-off units new series of motor operated shut-off valves for commercial and military aircraft, made by **Wm R Whittaker Co.**, Los Angeles feature synthetic ring-type fluid seal to provide leakproof performance under pressures up to 200 psi and temperatures of −65 to +450 deg F Powered by explosion-proof motor valves are available with operating times of 1 to 60 sec , accommodate wide variety of AN pipe sizes and tubing connections and can be used with fuel, oil, water, air, or vacuum lines

Trim Tab Control 8

Known as "Trim-Trol" new motorized actuator specifically designed for aircraft trim tab operation is announced by **Airborne Accessories Corp.**, Hillside N J Intended for operation with 28v d.c power unit employs novel method for effecting increase in me-

Truarc Beveled Ring takes up end-play, eliminates shims, saves 20 minutes' assembly time



TACHOMETER GENERATOR—Reliance Instrument Division, the Square D Company—showing Waldes Truarc Beveled Retaining Ring

When installed in a groove with a corresponding bevel, the tapered edges of the Beveled ring acts like a wedge and rigidly bridges end-play. End-play can also be taken up resiliently by another type Truarc ring—the Bowed.

Wherever you use machined shoulders, nuts, bolts, snap rings, cotter pins—there's a Truarc ring that does a better job of holding parts together. All Truarc rings are precision engineered, easy to assemble and dis-assemble, always circular to give a never-failing grip. They can be used over and over again.

See what can be done for your product: send a drawing to Waldes Truarc Technical Service Engineers for individual attention without obligation.

One Waldes Truarc Beveled Retaining Ring gives Five big advantages:

- Secures the cover with its connecting parts in the housing against strong pressure, heavy vibration
- Absorbs accumulated tolerances up to .010 (ring diameter is 1.9375)
- Eliminates shims, saves material and weight
- Saves 20 minutes' assembly time
- Simplifies field maintenance by facilitating quick dis-assembly, re-assembly

Mail this coupon today for your copy of "New Development in Retaining Rings"

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chanical advantage with increase in load and is thus adaptable for wide variety of applications Connected directly to tab with simple self-aligning link device requires no screwjacks cables or other mechanisms to transmit effort

Insulating Blankets 9

Designated "Thermoflex" new high temperature insulating blanket, developed to withstand starting temperatures on inside face as high as 2000 deg F, is made by **Johns-Manville Corp.**, New York City, for use around engine cones, turbine casings, and tail pipes of jet craft. Besides improving

thermal efficiency of engine, material is intended to protect adjacent structural members by maintaining temperatures below 200 deg F Flexible, material is basically special asbestos fiber mat shielded with metallic membrane and enclosed in wire mesh Cutouts are provided to accommodate engine supports, thermocouples, and other engine controls

Wind Indicating System 10

Combining wind vane and propellor type anemometer "Windial" is new indicating system developed by **Friez Instrument Div, Bendix Aviation Corp**, Baltimore, Md Placed outdoors in wind

flow, device transmits wind speed and direction to small indoor indicator having two illuminated dials for continuous indication of wind in mph. and direction in degrees of compass. Indicator plugs into standard 115v a.c. outlet

Unloading Pump 11

Eliminating check valve, relief valve, unloading valve and pressure accumulator, with resultant reduction of weight, new unloading pump for aircraft hydraulic systems is announced by **Pesco Products Div, Borg-Warner Corp.**, Chicago. Gear type pump is essentially two pumps in single housing Pilot valve, integral part of pump assembly, controls opening in passage communicating from outlet port to rear of movable bearings in pump cover When specified pressure is reached in system pilot valve closes passage to rear of bearings, to eliminate pressure loading Pressure in gear teeth area forces cover bearings away from gears and large section of pump ceases to deliver fluid with consequent decrease in hp input requirement Pump small section continues to deliver fluid pressure to keep system alive Excess fluid beyond requirement to offset system leakage is returned to reservoir by integral relief valve When hydraulic actuator is required and selector valve is operated, system pressure begins to decrease As system pressure falls to lower limit at which pilot valve is set, latter opens communicating passage, pressure is again exerted on rear of floating bearings in front cover, and pressure loading is reestablished in large section of pump Pump continues then to deliver full capacity so long as requirement exists

Aircraft Seats 12

Designed and strength-tested to meet CAA's latest requirements for air transport seating, aircraft new seat models, designated as Model S11-A

(single) and Model S23-A (double), are announced by **L. Potter, Inc.**, Bethpage, N Y Features are fire resistant upholstery replaceable arm rests, removable magazine pocket in seat back, floor fittings for quick removal or installation, and adjustable backs.

Battery Box 13

Having stainless steel interior for outlasting boxes made with ordinary materials and to eliminate acid proof paint coatings, steel aircraft battery box is announced by **McDowell Mfg. Co.**, Pittsburgh. Box lid-fasteners require no tools for release Unit is available in sizes 1, 3, and 5

Fire Extinguishing System 14

Spray nozzles, located over individual hazards or spaced equi-distant throughout area to be protected, are incorporated in new foam fire-extinguishing system made by **National Foam System, Inc.**, Philadelphia, for use where any flammable liquids are stored and where water sprays would tend to spread fire. Equipment may have its foam supplied either from a fixed independent unit or through permanent piping hooked up to a special foam truck Deflectors are made in three sizes for four water pressures Units consist of a brass foam maker with steel discharge tube and brass dispersion head, fitting standard pipe lines and finished in red Although usually assembled vertically onto overhead pipe lines with dispersion heads down deflectors may be placed at various angles for special applications Preferred operating pressure for all overhead spray units is 50 to 75 psi Extinguishing liquid is produced when 0 6% liquid is mixed with 9 4% water (fresh or salt) and 90% air At 50 psi water pressure area protected by overhead spray deflector varies from 47 to 150 ft., depending on type model

Steerable Tail Wheel 15

Offering positive action at any ground speed and full swiveling for ground-handling of light planes new steerable tail wheel is made by **Decker Mfg. Co.**, Los Angeles Maker reports taxi tests show device will not go into full swivel without using full rudder and brakes even when craft is intentionally ground-looped up to 90 deg Dustproof packings are used

Nylon Cable 16

Aviation applications are seen for new nylon cable made by **Danielson Mfg Co**, Danielson Conn., to provide strength, flexibility, and wearing qualities Cable available in two sizes,

5/32- and 7/32-in o.d., both with 3/32-in aero steel wire rope core, of 520 lb break test. Laboratory tests report cable withstands 320,000 flexings before steel core breaks, and 410 000 before nylon severs Resistance is claimed to oils, acids, moisture, salt water, friction and fire and freedom from fraying, rusting, or rotting

Contour Gage 17

Designed for checking cam contour of centerless cam ground pistons, "Electrolimit" contour gage made by **Pratt & Whitney Div, Niles-Bement-Pond Co**, West Hartford, Conn, is two-station gaging fixture Unit consists of floating pressure shoe arbor mounted on a slide so that arbor may be pulled out to install piston for gaging Arbor

(*Turn to page 111*)

AVIATION READER'S SERVICE JUNE 1947

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Douglas DC-4 Lubrication

Simplified by Sinclair

Sinclair's popular DC-4 Lubrication Chart, based on 15 years of practical experience, is a major step toward simplification of aircraft lubrication. It enables maintenance crews to do a thorough, safe, commendable lubrication job on every mechanical detail of the giant DC-4's, with *just four lubricants!*

In this way, lubricant inventory is held to a minimum . . . maintenance costs are kept appreciably lower. Write for your free copy of this useful, time-and-money saving DC-4 Lubrication Chart.

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Commercial airlines, private fliers, and aircraft manufacturers have found top-quality SINCLAIR-AIRCRAFT OIL just as dependable in peace-time aviation as it was proved to be in bomber, fighter, and transport engine lubrication during the war.

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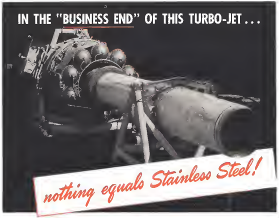

FABRICATED of Stainless Steel, this jet tail-pipe of the Ryan FR-1 Fireball Navy fighter, blasts a 1000 m.p.h. "tailwind" at a temperature of 1000°F. This hurricane of searing exhaust gas, which would destroy the airframe structure if unleashed, is channeled safely within walls of heat-resisting Stainless Steel.

Stainless Steel is also indispensable for the combustion chambers which run the engine and generate the high temperature exhaust which propels the Fireball in flight.

For similar critical applications, where Stainless is the only material that has proved satisfactory, U S S Stainless Steel offers unsurpassed service. Used by leading makers in exhaust stacks, collector rings, venturi cowlings, in flash boilers, etc. it ensures high creep strength at elevated temperatures. It produces no harmful oxidation scale. It provides superior resistance to corrosion, wear, cavitation and fatigue.

The various U S S Stainless Steels developed for aircraft use are so rigidly controlled in analysis, in finish and in fabricating qualities that they permit the widest latitude in design and allow the use of the most advanced manufacturing techniques. The result—equipment that will deliver the utmost in performance. Our engineers will be glad to cooperate with you in solving new and unusual problems in the use of Stainless.

U·S·S STAINLESS STEEL

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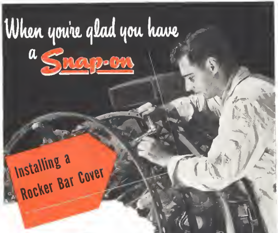
CARNEGIE-ILLINOIS STEEL CORPORATION, *Pittsburgh and Chicago*
COLUMBIA STEEL COMPANY, *San Francisco*
NATIONAL TUBE COMPANY, *Pittsburgh*
TENNESSEE COAL, IRON & RAILROAD COMPANY, *Birmingham*
UNITED STATES STEEL SUPPLY COMPANY, *Chicago, Warehouse Distributors*
United States Steel Export Company, New York

UNITED STATES STEEL



Hard-to get-at nuts and bolts, so common in aircraft engine maintenance, are just "easy going" for the mechanic using Snap on tools . . . *and here's why*. For every nut-turning operation, there is a Snap-on tool . . . one that will reach way in . . . reach under . . . reach around corners . . . one that will grip securely, turn easily and safely.

Fashioned from the highest grade alloy steel, these tools are famous for long life and lasting service. They match the rigid requirements of aviation maintenance for speed, accuracy and safety and stand out as *the number one choice* of aviation mechanics everywhere. Available through Snap-on's nationwide, direct-to-user tool service.

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THE CHOICE OF BETTER MECHANICS

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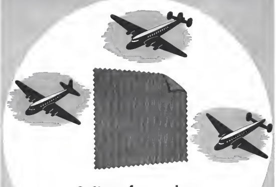

Salient facts about
BRIDGEPORT upholstery fabrics

Bridgeport fabrics are designed and woven specifically for aircraft upholstery and, therefore, give the maximum amount of service for the purpose for which they are intended.

Bridgeport fabrics are all wool. Therefore, it is unnecessary that they be flame-proofed

Bridgeport fabrics have a smooth, handsome appearance. They assure comfort regardless of posture of the passenger. This is important because many types of fabrics now being considered have been proved definitely unsuitable for vehicle upholstery for the reason that clothing clings to the fabric, resulting in marked discomfort.

Labor Costs. Upholstery departments tell us that there is considerable time saved in the fabrication of **Bridgeport** fabrics because of their careful construction. Time studies have shown as much as 20% saved in trimming over many other types of fabrics. This is true of our **Barkweave Bedford, Plain Broadcloths,** and **Heather Mixture** headlining.

BRIDGEPORT FABRICS, INC.

BRIDGEPORT 1, CONNECTICUT

Our One Hundred and Tenth Year

On the Boeing Stratocruiser
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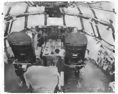

In the control cabins of all Boeing 377 Stratocruisers, where the best of everything is vital, specifications call for windshields of Pittsburgh Safety Plate Glass

NEW developments by "Pittsburgh" have kept pace with the American aviation industry's demands for special glasses, plastics, glass-and-plastic combinations and advanced glazing techniques

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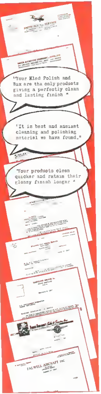

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The Lubrication Supervisor consults with a Gulf Lubrication Engineer (left) on results with Gulf L. S. Cutting Base A in tapping cold rolled iron magnet yokes for business machines.

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THE AVIATION NEWS

» **"Community company"** to operate overseas airlines probably will be defeated by anti-monopoly sentiment in the House, despite contention foreign airlines will furnish competition. The Air Coordinating Committee and the President are against it.

» **Sea-Air Committee** also seems in for defeat in fight for certification of shiplines to fly planes. Adding aircraft to merchant marine would reduce the fleet, not increase it. The Committee and airlines are joined against community company, but fight each other on sea-air issue. A presidential veto probably awaits sea-air and community company proposals, should either be approved by Congress.

» **Domestic routes for PAA** stand small chance of approval by CAB, though company argues competition by 31 overseas routes, U. S. and foreign, will be much greater than on domestic runs if its applications were allowed. PAA will re-beat its drive for chosen instrument if domestic route application fails.

» **Total overseas airlines** serving the U. S., including domestic and foreign, will be 9 on Atlantic, 7 on Pacific, and 23 Latin American. PAA concedes it now holds 90,000 of 161,000 total U. S. overseas route-miles.

» **Rapid recovery** from travel slump, plus 10% rate increase, is helping airline revenue to catch up with rising costs, helping squelch community company argument, and encouraging manufacturers of transport equipment. Airline prosperity will perk up surface-transport opposition that wants to hobble air operators with taxes and regulations, airport and avigation costs.

» **Some airfreight forwarders** regard ATA's opposition to CAB's proposed temporary exemption of forwarders as an attempt to shut out competition. The indirect carriers contend they can generate new cargo for certificated lines as well as for un-certs, and that their selling costs are lower. ATA says need for forwarders is not shown, but if they are exempted, they should be required to ship over lines that have filed tariffs—meaning certificated airlines. It's a dog fight.

» **Pooled airline maintenance** is growing and could in time embrace major portion of the industry. Examples are Pacific Airmotive engine overhaul at Burbank, with 30 big and small customers, and Aviation Maintenance Corp., both engines and airframes, at Van Nuys, Cal. Terminal and traffic service pools also are growing, and other cooperative movements are in the offing, like company long range radio.

» **Uncertificated freighters** won point before CAB that their service flexibility is superior to that of fixed-route operations. Two public counselors agreed mere cargo space available does not prove certificated lines can fully develop cargo potentials. Airlines services are designed for passengers and mail. Freighters now hope to beat airline drive to exclude them from common carrier privileges.

» **Upswing in airline revenue** barely saved CAB from a hot seat on demands for higher mail revenue to bail operators out of trouble. Overall mail rate increase will be moderate. CAB Chairman Landis says airmail balances at Post Office are "pretty far in the black." P.O. airmail figures, now as always, depend on who's figuring. For one thing, the balance was warped favorably by military flying of war mail, for which P.O. collected stamp money. Mail pay would be divided into "compensatory" and "subsidy" categories if bills before Congress are passed. And the U. S. Accounting Office would check "efficiency" of lines drawing subsidy—a word that would have to be defined.

» **GCA-ILS controversy,** if you can stand any more, tapers off with CAA approval of both radar and air instrumented approach for schedule airline use. AAF will have 72 GCA stations functioning by year end. Technicians, who knew that both systems held promise and that each had to be exhaustively tried out, were disgusted with the "amateurish wrangle."

» **Latest aid instrument offered** was Howard Hughes' radar obstacle warning system, hefting only 16 lb. per installation. Fitted in plane's nose, its search pattern is hemispheric, forward and down. When, during flight, obstacles are "spotted" by this terrain clearance indicator (at either 2,000 ft. or 500 ft. ranges), pilot gets warning in cockpit via blinker light and horn. First sets are going to TWA, in which Hughes is principal stockholder.

» **Watch castering wheels** for crosswind landing. They may reduce cost of airports by permitting use of single runways, might even alter present airport program. CAA is putting swivels on one of its DC-3s. Enclosed in wheel hub, caster does not hinder retraction. Other projects: Fairchild PT trainer, Goodyear hub on a Cub and on a Navion, Firestone on an Ercoupe; and All American Avi-

COPTER AIRMAIL CARRIER

Here's Bell company's Airmaster, specifically designed for use on new helicopter routes proposed by P.O. Dept. We are told that new craft carries 500 lb. of airmail plus adequate fuel to cover any routes considered for N.Y.C., Chicago, and Los Angeles vicinities. Recently licensed, Airmaster carries its postal load in two conveniently located "saddlebags" just behind pilot on either side of fuselage. Hooks are provided for mail pouches, and compartments (of 12-cu. ft. capacity) are detachable to permit access to engine.

FOR PROBING THE TRANSONIC

Model airplanes, designed for dropping from a mother plane (in this case a Boeing PB-1W) are being used by Naval Air Experimental Station, Phila., for gathering data on aerodynamic phenomena to be experienced by craft traveling at transonic speeds. Grumman Bearcat replica is seen here. Its diving characteristic is aided by placement of 500 lb of lead in nose, and automatic controls pull it out at speeds of over 600 mph. A parachute is fitted for reclamation of model following each trial. Telemetering equipment fitted in small craft and ground-operated radar are utilized in gathering flight data. (U.S. Navy photo)

ation on a Beechcraft. Major credit goes to John Geisse, who has bucked complacence on the subject for years

» **Electronic flight aids** of the future may show up CCA and ILS as crude beginnings. There's airborne radar, Teleran, Lanac, CRS, Naviglobe, omni range, DME, Navar, VHF direction finding, and what else. What new and better flight controls may come out of them is your guess

» **Lightplane sales prospects** apparently must get worse before manufacturers will go for CAA-sponsored utility improvements. Response to CAA proposal that Congress be asked for $1,000,000 for experimental features, got a tepid reception. Mainly, producers don't like sharing CAA developments. Anyway, while airport and avigation benefits are being attacked as subsidies, Congress will shy at appropriations for private aviation industry. The defense angle wouldn't work just now, but it might later.

» **The progressive school**, or name it yourself, is vociferous for trying roadable planes, rotary wing, jet rotors, combination wing and direct lift, and anything that might fly. They contend it's now clear conventional planes will not make a mass market, that the industry is aimlessly shifting from 2- to 4-placers, from sport prospects to business men, and that it will fail. Little guys are doing most such pioneering.

» **AAF's 500-mph jet bombers** now total five: North American XB-45, Convair XB-46, Boeing XB-47, Martin XB-48, and Northrop XB-49. All are powered by GE-Allison J-35 engines. The XB-45 and XB-46 have 4 jets, XB-47 and XB-48 6 jets, and the XB-49 8 jets. Roughly the size of wartime heavies, but by new standards called mediums, they carry around 10-ton bomb loads. These and a complete line of Army and Navy jet fighters move military aviation toward a minimum of piston engine power

» **Military aircraft procurement** is small, and probably will remain so unless world politics worsen. Meanwhile the industry must live mainly on research, especially after the 700-plane transport program dwindles. It's bad news, but the industry will have to stay in cutback status, perhaps for a long time. Answer to aircrafter's protests is that they're getting a huge slice of total defense money

» **How A-bombs would be delivered** against targets is splitting opinion between AAF and Navy. Army thinks long-range strategic bombardment can do the job, sufficiently evading whatever interception may be devised, including proximity fuses. Navy—seeing long range aviation and missiles as a threat to its one remaining major element, carriers—contends strategic bombing is obsolete and that land and deck-based short-range planes and missiles will carry the war heads

» **Underground plants**, already studied by Army and Navy, are under further investigation by AAF, which says Nazis' 13-ft concrete roofs were not busted by Allied bombs till near war's end. So far, U.S. military likes underhill excavation best, finds caves and mines badly located, uneven, often wet. War officials shiver at press interest in subterranean plans and will keep quiet when they decide on a plan. —Blaine Stubblefield

Worldata

CANADA—Trans-Canada Air Lines reports 1946 deficit of $1,115,256, largely accounted by 32% drop in annual volume, causing line to lose $2,000,000 on its pound-mile mail contract with Post Office. . . . A. V. Roe Canada is working on twin engine 30-passenger jet transport to travel 400 mph. It expects to have craft ready for test in summer of '48. Company also is busy on two new jet engines and a new high-speed long range jet fighter for RCAF. . . . Government and municipalities have drafted new subsidy arrangements for municipal operation of airports. Revised charges have been announced for Department of Transport airports, with planes under 5,000 lb. paying no fees for landing

ENGLAND—Public opinion has forced cancellation of plans for Bristol-powered Constellations. Further, there is now acceleration of process of eliminating all U.S.-built aircraft from British airlines, one of initial steps being re-assignment of 12-yr-old Junkers Ju-52s to take place of DC-3s on BEAC's London-Belfast route. Other DC-3s are to be replaced shortly by Vikings. Meantime, rumors indicate BOAC's Connies will be sold to other lines and replaced by Tudors, if latter craft can be made acceptable for trans-Atlantic travel. . . . Resignation of Lord Knollys as chairman of BOAC resulted in important administrative changes in both this company and BEAC. Sir Harold Hartley is new BOAC chairman, and Mr. d'Erlanger becomes chairman of BEAC. . . . British government subsidies to its airlines will amount to $30 million in coming fiscal year—$7 million more than in previous period

SCANDINAVIA—Plans have been completed for bases which Scandinavian Airlines System intends to operate by 1948 Boeing Stratocruisers (routes over Atlantic) will fly from Sola, Norway; Douglas DC-6s (routes to South America, Australia, and Far East) from Halmsjön, Sweden, and DC-4s (to Africa and for charter operations) from Kastrup, Denmark.

GREECE—TWA, BEAC, and Greek interests are joining in formation of airline to operate domestic and internation Greek routes

ITALY—New cooperation between British and American air line interests brings hope that wasteful duplication of air service in Italy may be avoided by formation of a single Anglo-U.S.-Italian company to replace individual British and American sponsored airlines

SWITZERLAND—Merger of Swissair and Alpar, two most important Swiss airlines, is being completed

HUNGARY—Three short internal air services are now in operation, totaling some 360 mi. Planes used are LI-2s, Russian copies of DC-3 type. It is hoped international relations may be smoothed so routes to Vienna and Bucharest may be opened.

AUSTRALIA—All airports have now been taken over by the government, which henceforth will maintain and control them. . . . Some $120,000 will be spent to provide modern radio and radio teletype connections between the fields of the country. . . . Improvement of Moreton Airport, on Australia-Tokyo route, has been delayed by trouble with Indonesian rebels, who have been sabotaging both Dutch and Australian aircraft, necessitating RAAF guard duty

Underwing Fueling And How It Was Engineered

By ERIC OLSEN, *Manager Aviation Div., Wayne Pump Co*

Realistically weighing design obstacles and operator-posed objections which this improved fueling system had to surmount, Manager Olsen reveals development of the efficient servicing method, and details characteristics of its vital components.

For several years past, much effort has been expended in the investigation of high speed underwing fueling for large aircraft. Results of the studies point to the economic necessity for this type of fueling. The armed forces have been quick to recognize its feasibility for combat and transport aircraft, and have conducted additional exhaustive studies covering maximum flows and safety devices. The aviation industry, however, has been somewhat reluctant to embrace the program or evaluate its potentialities.

Principal doubts voiced by the airline operators in connection with this new method of fueling are concerned with: (1) Extent of design changes on new aircraft, necessitated by incorporation of in-the-wing fittings, safety devices, and other system features, (2) element of safety with reference to the airplane and also to ground crew handling fuel at the new high flow rates, it being frequently pointed out that lack of safety devices designed to prevent wing rupture because of overfilling or pressures resulting from entrapped air or vapor, would pose a difficult and expensive problem, and (3) formidable-appearing aspects of introducing underwing servicing for airline aircraft throughout the world—considering difficulties during the period when both overwing and underwing fueling must be provided until adequate, standardized equipment is available.

Without minimizing the magnitude of these objections, it is safe to say that each has been overcome to the point where satisfactory equipment may be obtained and installed both in aircraft and on the ground, to safely and economically accomplish desired results

The newer large planes have exceedingly light skin on leading edges and wing top surfaces. This design feature, coupled with the present height of wings from the ground, makes handling of heavy hoses over such surfaces impractical. It is likewise dangerous and destructive for ground handling crews to have to walk atop wings

General consensus of the industry is that at least 200 gpm. of fuel should be introduced simultaneously into each wing if sufficiently rapid fueling is to be obtained. To accomplish such flows with the necessary minimum pressures, requires at least a 2½-in. hose at each intake connection. Because of construction features it is not safe to submit wing tanks—especially integral tanks—to more than 5 psi. maximum, from any source whatsoever. Impact loads due to fuel velocity and nozzle pressures must be kept to a minimum. Hence, only a large size hose will meet these requirements

View under tank mock-up, with safety cap removed from tank fueling valve. The 2½-in hose nozzle is shown in position, ready for attachment to tank nozzle valve

Fortunately, equipment manufacturers have made considerable progress within the last two years in the development of fueling units which are reliable in operation. Design problems, which in the past have seemed to be a stumbling block to the adoption of underwing fueling, have been greatly minimized by these developments. Airframe manufacturers now find that very few structural changes are necessary. And in some instances, substantial weight-saving has actually been effected.

Safety devices for protection of the wing no longer present a difficulty. There are now being manufactured at least four types of devices which adequately protect wing tanks, and also afford safety to ground crews. Tests—embracing many thousand cycles—by various airframe manufacturers have shown that these devices adequately perform their intended function

Actually, studies seeking answers to the operators' objections provide the story behind the development of underwing fueling. Results of these studies are summarized here in an effort to present a clear picture of the problems involved and the solutions obtained.

Aircraft design problems presented the first hurdle. It became immediately apparent that some standardization on fittings would be necessary before the airframe manufacturer could hope to effect a design which would be satisfactory to the ultimate user. This standardization was brought about by NASC's subcommittee on underwing fueling connectors, following a meeting in Detroit, in Feb. 1946, at which time a tentative set of specifications

were presented to, and adopted by, ATA's engineering committee.

Using the standard in-the-tank fitting and the specified in-the-tank pressures and impact loads as criteria, the airframe designer found that little or no change was necessary in structure to accommodate the flanged ring with valve and diffuser cap (shown in an accompanying illustration). Where considerable weight addition had been anticipated, it was found that at most but a pound or two was added. Also, it was found that very little beefing up was necessary to provide sufficient strength of structure to withstand the hose weight plus fuel flow stress.

About this time, Wayne Pump Co introduced a rapid fueling system under the trade name of Collaps-a-Hose. Featured is a collapsible line, of the fire-hose type, which is about one-fourth the weight of the conventional hose of the same size and capacity. Through use of an electronically controlled, hydraulically operated valve system, the Collaps-a-Hose unit completely evacuates the hose after each serving, allowing it to be reeled in the same manner as fire hose.

Unique feature of the system is the manner in which the electronic control functions. As in all fuel hoses, Collaps-a-Hose contains a grounded static wire. This wire automatically completes the operating circuit of the electronic control once the underwing fitting is attached to airplane wing. Hence, fuel can only be served to the craft when both it and the serving unit are properly grounded—thus automatically complying with the strict aircraft-fueling rule set up by CAA and airline operators. Current necessary to operate the system is but a few milliamperes, at no time sufficient to cause spark to ignite fuel or vapors.

The system has a pre-set counter which allows predetermination of fuel quantity desired and automatically shuts off the equipment and evacuates the hose when that amount has been delivered to the plane. Basic unit of the Collaps-a-Hose system is a new type high-lift centrifugal pump (developed by Robert J. Jauch, company v.p. in charge of research and development, also inventor of the hose) which can bypass fuel for an indefinite period without damage to equipment—a safeguard, if field personnel forget to shut off the pump. The pump also eliminates air from the fuel before latter is served to the tank, metering only liquid. Presence of entrapped air, that causes difficulties at high altitudes despite condition of fuel equilibrium on the ground before takeoff, is thus greatly minimized.

Within the past 1½ yr., Collaps-a-Hose has been placed in operation in the field—on tank trucks and in pits. Shell Oil, in conjunction with Glenn L. Martin Co., conducted numerous tests on the Martin 202, first of the new aircraft to have underwing fueling incorporated as original design. Results have been highly satisfactory. Pressures under 5 psi. inside the tank were obtained with flows well above 200 gpm. Both Carter and Parker fittings were used during the tests, and both performed satisfactorily.

First carrier to install underwing fueling facilities across its system is Northwest Airlines, using Collaps-a-Hose exclusively.

At Mills Field, South San Francisco,

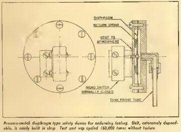
Parker in-the-tank unit and accompanying safety float device which shuts off fuel flow when proper level is attained

Standard Oil of California has placed a Collaps-a-Hose pit system in operation for United Airlines, and this installation is also proving satisfactory.

Problem of safety in connection with wing tank filling was not as easy of solution as were craft structural design changes. However, four types of safety shutoff devices have been generally tested and found satisfactory—(1) Float type, (2) pressure diaphragm; (3) electronic, and (4) weight-of-head, or pressure type.

Both Parker Appliance Co. and Liquidometer Corp. build a float type shutoff which depends mainly on height of fluid in the tank to operate valves

Left: Latest type Collaps-a-Hose unit (hose not shown) with pre-set counter and electronic control (A) to actuate grounding line. Installation is capable of handling 225 gpm., with safety to plane and ground crew. Counter causes flow shutoff and evacuation of hose when predetermined fuel quantity is delivered. Solenoid (B) actuates four-way valve to change unit from flow to suction. Underwing defueling at rate of approximately 60 gal./min. may be had. Right: Shell truck installation provides 200-gpm flow from each of two hoses. Attendant is seen attaching one hose; other hose (reeled) is visible through open panel doors in truck side. Craft is Martin 202.



Pressure-switch diaphragm type safety device for underwing fueling. Unit, extremely dependable, is easily built in shop. Test unit was cycled 150,000 times without failure

Carter fitting with handle in closed position and Collaps-a-Hose evacuated after fueling test at Douglas. Center section of actual DC-6 wing was used to determine tank pressures and vapor-air quantity.

or electronic devices halting fuel flow. Tests on the Parker equipment at the Martin plant, and on the Liquidometer installation at Douglas, showed them capable of halting 200-gpm. flow of fuel in the minimum time required to prevent overfilling of tanks and attendant dangerous pressures against wing structure.

One of the simplest and most effective safety devices is a simple diaphragm and microswitch. With this installation, either fuel or air-vapor mixture rising in the tube within the tank causes sufficient pressure differential to operate, by instantaneous electrical means, the diaphragm and switch controlling the equipment. This unit was cycled 150 000 times without failure. It is capable of very accurate adjustment and has advantage of controlling both fuel level rise and pressures within the tank. And it is easily manufactured by the operator in his own shop.

The Thos. A. Edison Co., Minneapolis-Honeywell, Simmonds, and others, manufacture electronic fuel gages which can easily be adapted for control of fuel levels within the tanks, through the capacitance-measurement method.

James Coolidge Carter Co. is designer and maker of the fourth type of safety shut off device—the weight-of-head unit. Here the column of liquid above the device acts upon a pressure-tripping mechanism, opening a valve which remains open and discharges fuel from the tank so long as pressures are above normal setting. Both pressure of entrapped vapor and air and the head of fuel affect the operation of the unit. Operators object to the discharge of fuel on the ramp, causing a fire hazard, but admit this condition is better than rupturing a wing.

For the rapid underwing fueling of aircraft throughout the world, time will solve the problem of standardized equipment. As more and better equipment becomes available and more and more aircraft provide underwing fueling connections, the problem will solve itself. Even now, combination nozzles have been developed to allow underwing fittings to be used for overwing fueling.

Certain salient features of underwing fueling cannot be overlooked. With inoperative time of large aircraft creating sizable financial considerations, speed of ground handling is a necessity. Safety is at all times paramount. And economy is essential.

Field operation shows that despite ever-growing tank capacities, fueling time can be more than halved through use of larger hoses and greater flows. Tests have proved that 200 gpm. of fuel can be introduced into an aircraft tank with less attendant vapor than from 50 gpm. served overwing. Safety devices now perfected provide safer operation at high flow than is now obtained with present low-flow high-pressure systems. Underwing fueling is unquestionably here to stay.

Carter in-the-tank unit and automatic safety device shown installed with Carter hose fitting attached. Head of air and fuel causes unit to function

Super Altitude-Research Rocket Revealed by Navy

By C. H. SMITH, JR., M. W. ROSEN, and J. M. BRIDGER,
Naval Research Laboratory, Office of Naval Research

First engineering study gives constructive details of Martin-built Neptune, research missile being built to double ceilings reached by V-2s.

Designed to carry research instruments to new record heights of better than 1,000,000 ft., a new rocket called the Neptune is being constructed for the Navy by Glenn L. Martin Co.

Reaching for such altitudes—some 100 mi. higher than the highest V-2 flight thus far—posed design and construction problems never before encountered, and discussed here for the first time.

In the design of a high altitude sounding rocket, one must remember it is not to be used as a weapon, but as a research vehicle to serve as a platform from which measurements may be made. Such a vehicle should be constructed as simply and efficiently as possible, have reasonably low acceleration and vibration, low overall weight, and high specific impulse. Specific impulse here refers to the ratio of thrust (lb.) to weight-rate of propellant flow in combustion (lb. per sec.). Principal characteristics of the Neptune are shown in Table I.

Comparison of known propulsion systems, in light of those requirements, led to choice of a single-cylinder liquified oxygen-alcohol rocket power plant with turbopump propellant injection system. Calculations indicate that to meet payload and maximum altitude requirements it will be necessary for the engine to deliver 20,000 lb. thrust for 75 sec. or, to put it another way, that specific impulse must continue for 210 sec., assuming propellant flow and burning rate to be constant for the entire burning time. Engineers of Reaction Motors, Inc., who were chosen to develop the Neptune's engine, have indicated a system meeting these requirements can be built.

It is estimated that the power plant, less piping, will weigh 250 lb., have overall length of about 44 in., and nozzle-exit outer diameter of approximately 19½ in. With a nozzle expansion area ratio of 4.3, mean mixture ratio (of the alcohol/liquid oxygen by weight) of 0.90 at sea level, and average consumption of alcohol and liquid oxygen of 45.1 and 50.1 lb./sec., respectively, it should be possible to attain the desired specific impulse.

The 4.3 nozzle expansion area ratio was selected over larger ratios—because of the latters' disadvantages, such as jet flickering, greater cooling problems, and overall nozzle exit size—with relatively small loss in altitude performance (about 1%) associated with less than optimum expansion at higher altitudes. A 4.3 ratio corresponds to an average back pressure of 0.8 atmospheres, compared with 0.86 for the V-2.

Table I—Neptune Characteristics

Dimensions	
Length	543 in. (45 ft. 3 in.)
Diameter	32 in.
Span (across fins)	58 in.
Weight	
Total empty wt.	1,992 lb.
Fuels (alcohol, oxygen, H_2O_2 and Gs)	7,418 lb.
Payload	100-2,000 lb.
Total gross wt.	9,510-11,410 lb.
Performance*	
Altitude	1,235,000 ft.
Velocity (max.)	8,200 ft./sec.
Time to max. altitude	335 sec.
Acceleration (max.)	10.87 g
Time to max. altitude	335 sec.
Thrust (max.)	22,800 lb.
Specific impulse (max.)	247 sec.
Duration of thrust	75 sec.
Propellants	
Alcohol	3,380 lb.
Liquid oxygen	3,700 lb.
Hydrogen peroxide	270 lb.

* With 100 lb. payload.

Originally it was planned to use an alcohol-water mixture as fuel, but tests have brought a tentative decision to use straight alcohol. This will bring a 15% change in optimum weight mixture ratio, and resultant decrease in overall weight and increased specific impulse. Linde commercial liquid oxygen, or the equivalent, will be used.

The turbopump propellant injection system was chosen over a pressure feed system, despite higher cost. A large weight saving and, coupled with it, better predicted performance were felt to outweigh the cost difference. Both alcohol and liquid oxygen pumps will be driven at about 10,000 rpm. by the turbine rotor on an integral shaft.

The turbopump is driven from the decomposition products of high concentration hydrogen peroxide. The hydrogen peroxide, stable at high concentration, will be held in a tank shaped as a helical coil spiraling around the turbine chamber. A pressure of 415-465 psi. absolute, derived from the gas pressurizing system (to be discussed later), will force the peroxide into a gas generator, where its decomposition is initiated on contact with a manganese compound, with the resulting steam driving the turbine. The product of decomposition is also used to correct rocket roll (as described later).

Adequate flow of all fluids is assured by a pressurizing system using helium at pressures of 3,500 psi. Control valves and regulators will maintain pressures (absolute) as follows: Alcohol range, 30-26 psi.; oxygen range, 33-9 psi., and hydrogen peroxide range, ± 5 psi. of a fixed value (to be determined) between 415 and 465 psi. Pressurizing all fluids was necessitated by cavitation danger resulting from high fuel consumption rates and the requirement that fairly constant pump inlet pressures be maintained. Helium was chosen because of its low density and low affinity for the fluids to be pressurized. Helium required will weigh about 8 lb.

By relocating the oxygen tank forward, it has been possible to increase considerably the pressure head at the oxygen pump, thus reducing the problem of cavitation with the boiling oxygen.

The rocket engine will be started by an electric signal to a standard squib-type igniter through a pull-away plug. Termination of engine operation will result from activation of either turbine overspeed switch or emergency cutoff relay receiving a signal from the ground, or internally from a timer—whichever method is most desirable.

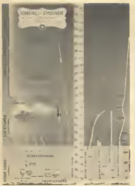


Fig. 1. Comparative chart showing 200 mi. altitude regions to be explored by Navy's Martin-built rocket Neptune, slated for flight next summer.

Fig. 2. Artist's conception of Neptune rocket at moment of launching. It will quickly attain supersonic speeds in its dash to altitudes of better than 1,000,000 ft. as carrier of research instruments.

One of the first decisions necessary was selection of the general shape of the rocket body. On the basis of preliminary structural and fabrication studies, a design based on a simple ogival nose and straight cylindrical body was chosen. Studies indicated that no severe structural difficulties would arise from large length/diameter ratios, such as 15.18:1. Supersonic wind tunnel tests indicate that for a given volume the drag variation with L/D ratio is very flat from 11:1 to 18:1. Fin weight penalties for required stability have indicated no real optimum.

A 32-in. dia. was chosen on the basis of engine diameter, volumetric efficiency of components, and ease of construction from maximum width sheets of suitable aluminum. With that diameter, required volume can be housed in a vehicle 543 in. long, putting L/D ratio at approximately 17:1. A conical nose of 25-deg. included angle was chosen on the basis of drag considerations and other requirements based on uses planned for the rocket.

Next problem concerned stability, a difficult factor on such a rocket which must be designed to fly through density variations from atmospheric to practically zero, and at all speeds up to supersonic. Basically, two types of tumbling may be exhibited by missiles of this type.

End-over-end, simpler of the two, can be predicted fairly easily. The rocket may show this behavior early in flight before appreciable speed is attained, and then again as the atmosphere's influence is lost. The second type of tumbling consists of motion in all three planes, in which the rocket rotates about both C.G. and longitudinal axis.

Analysis of wind tunnel models indicates the Neptune will be stable through the expected speed range. Design of the first unit is based on L/D ratio of 16.85:1, with a tail structure of four fins having total area per plane of 30 sq. ft., aspect ratio of 1, sweep angle of 60 deg., and tip chord rake of 3 deg. (Aspect ratio here refers to the square of the external fin span divided by the total fin area in a given plane).

Aerodynamic trim tabs are planned for each fin. All tabs will be ground-adjusted prior to flight, and in addi-

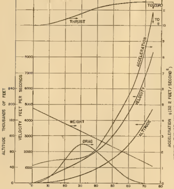


Fig 3. Calculated burning-time history of Neptune rocket based on takeoff weight of 9,510 lb. with 7,140-lb fuel load

tion the tabs in one of the planes are to be coupled to the thrust deflection servo system Fin airfoil section is a double wedge plus flat sections having all plane surfaces, with a 4% thickness ratio

Preliminary dynamic stability studies, which only considered the rocket's longitudinal oscillation about C.G. (e.g., restrained against lateral movement) have indicated the need for some form of automatic control to dampen oscillations except for narrow altitude ranges

Control system design considers such items as: Accuracy, reliability, interaction of control axes, gyro gimbal lock, and possibility of inadequate roll control Stabilization and control system have been designed to provide for correction for steady state and of transient error about both pitch and yaw axes and roll in either direction about the longitudinal axis.

It is planned to launch the Neptune vertically and introduce early in flight a tilt of 3-10 deg. to the North. This will define the pitch axis as being horizontally east and west through C.G., and yaw axis as being horizontally north and south

Past rocket experience has shown that, to insure adequate control, provision must be made to alter thrust direction in addition to the production of moments by aerodynamic surfaces

Thrust direction may be altered either by reorienting the combustion cylinder or by introduction of deflection surfaces into the jet stream, as the Germans did with the V-2. Both systems impose many design problems and, although the first imposes more stringent demands on the control system, it has been tentatively chosen due to anticipated performance improvement. In addition to eliminating thrust loss due to vanes in the jet, a weight saving of some 275 lb is achieved

Since stabilization and control of the Neptune are limited practically to vertical flight, its design should not prove as difficult as radio command steering Pitch and yaw gyro signal systems, to constantly measure deviation of the longitudinal axis from true vertical, are provided These feed a signal, proportional in magnitude to the error deviation, to a correcting mechanism

Pitch and yaw systems may be virtually identical. Each will consist of a sensing element (gyro), signal pick off, lead circuit, amplifier, and hydraulic servomotor By using double axis gyros having pickoffs and torquers on each axis, two units can be made to perform all position sensing required for pitch, yaw, and roll control

If a control voltage proportional to the error were fed to the correcting unit, steering action would be delayed due to lag and inertia in links of the system. Consequently, the phase of the correcting action must lead the error signal to attain stabilized operation A lead circuit is included to assure correct phase relationship The hydraulic servos will be driven by a hydraulic motor pump using alcohol from the high pressure side of the main fuel pump, with exhausted alcohol being returned to the main fuel tank.

Certain experiments planned for the Neptune will be more simple and effective if roll correction is provided While such correction is a problem

Cutaway drawing of HASR-2 Neptune rocket shows internal arrangement.

TABLE II—WEIGHT DISTRIBUTION

Item	Weight (lb)	
Body Group		555
Nose cone and instrument compartment	61	
Control compartment	33	
Oxygen compartment	104	
Fuel compartment	258	
Tail section	99	
Fins		210
Motor mount		57
Power plant group		871
Motor (RMI 20000 C1)	250	
Alcohol tank	(Included in body group)	
Oxygen tank	95	
Peroxide tank	50	
Main pressurizing tank	155	
Pump	140	
Gas pressurizing control system	40	
Piping, valves, etc	141	
Fixed equipment		299
Control system	241	
Electrical equipment and wiring	58	
Total empty weight		1,992
Useful load	7,918	
Payload (max)	100–2,000	
Alcohol	3,380	
Oxygen	3,760	
Peroxide	270	
Helium	8	
Total weight (gross)		95,810–11,140

with jet vanes, it is even more of a problem when the engine thrust line is altered. Aerodynamic trim tabs are practically useless on a missile going outside the atmosphere's influence

The problem is not, of course, sensing the roll, but bringing to bear a suitable counter moment Since considerable energy will remain in the peroxide turbine exhaust, it was decided to release this exhaust from roll jets at a distance from the longitudinal axis and in a direction to provide the necessary moment Jets are designed to release equal quantities of steam in opposite directions so as to produce no moment normally, but with the error correction signal, valves will operate in each jet to increase the steam exhaust on the side opposing the roll Since it is possible that roll may be induced after fuel burnout by deceleration of the turbine rotor (coaxial with longitudinal axis of the rocket), or from other causes, it was decided to extend roll control for 17 sec. This will be done by inserting, between the gas generator and turbine, a changeover valve which switches the gases directly to the roll jets at final burnout This requires a 30-lb increase in hydrogen peroxide supply.

Forward 77 in of the Neptune is reserved for research instruments The nose is a true cone of 25-deg. included angle for the first 44 in, where it has a dia. of 19½ in From this point the ogive begins, and maximum dia. of 32 in is reached at midpoint of the control compartment, 100 in. from the nose. Body aft of the 100-in station is cylindrical Base of the nose section (the 77 in station) is of 30 in. dia., and it is sealed by a magnesium casting Access is provided by two doors and the whole section can be pressurized Original design called for a skin of heat resistant steel, but this is being reconsidered in view of recent temperature data obtained from V-2 experiments, indicating possible use of aluminum.

From Station 77 to 120, space is reserved for instruments necessary for flight control: Gyros, batteries, cutoff receivers, control electronics, etc., and the helium sphere.

Between Stations 120 and 437 will be the fuel tanks, the forward one containing liquid oxygen The alcohol tank, just aft, is an integral part of the rocket structure, with its surface forming the rocket skin

All space aft of Station 437 is occupied by the turbine, peroxide tank, rocket engine, and hydraulic and valving equipment. Removable skin segments will give easy access to the engine compartment.

Thrust force of the engine will be carried through a steel gimbal ring to aluminum fittings between forward and center fin spar frames, to distribute both axial and normal components of thrust into the skin structure.

Performance calculations indicate that altitudes attained will considerably exceed those originally specified for the rocket At best, preliminary calculations can give only approximations of performance, since many of the Neptune features have not been tried before. Data on drag at the velocities and pressures calculated for the regions through which Neptune will pass, are very limited Wind tunnel tests at Ballistic Research Laboratory, Aberdeen Proving Grounds, have established outside limits on drag at Mach 1.72. Curves of drag coefficient vs Mach number were extrapolated from Mach 1.72 on the basis of the general trend known from German V-2 experiments and other data.

Calculated burning-time history of the Neptune is shown in Fig 3, under the following conditions. Launching at sea level, total takeoff wt., 9,510 lb.; fuel wt., 7,140 lb.; payload, 100 lb., specific sea level impulse, 210 sec., burning time, 75 sec.; max. cross section, 5.6 ft.; and highest anticipated drag on basis of wind tunnel data

Firing of the first Neptune is being planned for the summer of 1948, with a series of about one firing every other month after that. In addition to providing a vehicle for continuation of our high altitude research program, the Neptune may well help to prove the practicability of still higher soundings—or possibly even the practicability of extraterrestrial exploration within the forseeable future

Table III—Comparison Of Neptune and V-2 Performance

	Neptune				V-2
	100-Lb Payload	500-Lb. Payload	1,000-Lb. Payload	2,000-Lb Payload	2,200-Lb. Payload
Max altitude (ft.)	1,255,000	1,006,000	733,000	446,000	600,000*
Alt at burnout (ft)	180,000	172,000	150,000	115,000	100,000*
Burning time (sec.)	75	75	75	75	67*
Max acceleration (g)	10.9	8.8	7.3	5.8	6*
Max. velocity (ft sec)	8,200	7,260	6,070	4,570	5,200*
Total weight (lb)	9,510	9,910	10,410	11,410	28,380†
Propellant wt. (lb)	7,140	7,140	7,140	7,140	19,613†
Thrust (sea level) (lb)	20,000	20,000	20,000	20,000	52,200†
Useful payload (lb)	100	500	1,000	2,000	2,200†

* Values obtained in V-2 firings at White Sands Proving Ground.
† Derived from German V-2 literature (which it is noted, gives maximum vertical altitude of 512,000 ft. for a 67 sec. burning period)

Power "Dividends" Seen Available for Turboprops

By S. A. TUCKER, *McGraw-Hill World News*

Ingenious impulse-wave compressor increases power output and efficiency in locomotive unit; principles held applicable for turbine-powered aircraft.

A NEW FUNDAMENTAL gas-power process which may have important aircraft applications has just been revealed in Switzerland

Engineers of Brown Boveri Co have found a means of compressing air and expanding gas according to the same best process as in a reciprocating engine cylinder, but without use of pistons or other reciprocating parts.

Currently being tested, the pressure exchange unit known as Comprex is being employed as a second-stage compressor of a locomotive power unit, adding some 1,500 hp to the conventional gas turbine's 2,500-hp output and increasing thermal efficiency from a base of 18% (at 1,120 deg F gas temperature) to about 22%.

While it may seem a long way from the relatively heavy construction of locomotive application to the rigid weight requirements of aircraft, the fundamentals may well be adapted to airborne craft However, since Comprex provides additional shaft power without more air flow, it would probably find best application in turboprops rather than straight turbojets.

Comprex cannot be classified under any of the three basic compressor types—reciprocating, centrifugal, or axial flow. Work of compression is derived from a "piston" of hot gas which expands in the same "cell" used for compression Essential functions of the internal combustion engine are executed, but without pistons or reciprocating motion

Position of the Comprex unit in the gas-turbine cycle is shown in Fig 1, while Fig 2 illustrates its construction Essentially the unit consists of a number of cells, open at both ends, arranged around a shaft which is driven by a motor or other constant speed device This rotor turns between fixed plates which serve as valves Both air and gas enter through the plates at the left and leave at the right, so that flow through rotor cells is unidirectional and practically continuous.

Phases of compression and expansion are illustrated in Fig 3, which shows a development of the cells and connections in a plane. Cells, represented by horizontal bars, move downward at a rate of some 3,000 cells per sec past the air and gas openings in the fixed end plates

Air entering a cell (top of Fig 3) sets up a pressure wave that is considerably greater than its velocity head Thus a charge of air is trapped as the cell moves past the air inlet port Because of the pressure wave effect, the trapped air has greater total weight

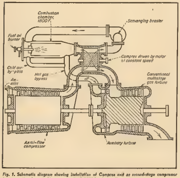


Fig. 1. Schematic diagram showing installation of Comprex unit as second-stage compressor for conventional gas turbine power unit of 4,000-hp. locomotive.

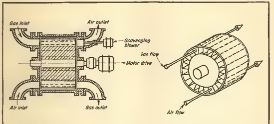


Fig 2 Only moving part of Comprex is rotor, having number of individual cells around periphery, as shown in perspective view. Each cell acts alternately as compression and expansion chamber for air and gas

than that corresponding to air-inlet pressure

Gas inlet is timed (by position of the gas-inlet port) so that a second compression wave forces air out at pressures approaching three times that of the air inlet. A charge of gas is then trapped at the low point of a pressure wave, and exhausted at the proper time to leave the cell at a lower pressure than the air inlet In the present model, a small scavenging blower (shown in Fig 2) aids flow and compensates for pressure drop in the combustion chamber

During each revolution of the rotor, each cell is exposed to temperatures ranging from relatively cold air at the inlet to hot gas at combustion chamber temperatures But because of the rapidity of the changes, metal temperature of the cell walls varies less than 4 deg F from the average of air and gas temperatures, and this temperature variation effect penetrates less than .004 in. of cell wall thickness Thus combustion gas at 1,800 deg F can be utilized in a cell designed for 1,025 F, well within limits of existing materials

Net power results from this cycle, because not all the hot gas is needed for air compression Comprex is essentially a constant-volume device, returning about the same volume of hot gas as intake air The remainder, tempered by addition of by passed air, is available for expansion through an auxiliary turbine (which could be geared to a propeller) Added power is obtained for less than half the weight-per-hp ratio of the main gas turbine

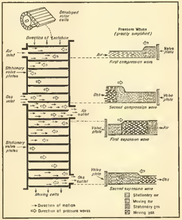


Fig 3 Schematic sketch (with cells "unrolled") shows simplified cycle of air and gas pressure waves formed as cells pass fixed valve end plates Compression ratio approaches 3:1.

Thermodynamic Factors In Turbine-Aircraft Design

By JOEL WHITNEY, *Thermodynamicist Ryan Aeronautical Co.*

Outlining vital cooling and ducting problems confronting the thermodynamicist in advanced power plant installations, Author Whitney goes on to present a succinct method of approach for their solution.

In aircraft design projects, the thermodynamicist is concerned, arbitrarily, only with internal flow problems and aspects of heat transfer within the envelope of the craft. This arbitrarily eliminates thermodynamic relations which occur in external high velocity flow problems, and leaves flow considerations of intake and discharge ducts and entrances, flow and heat calculations through engines and accessories, heat transfer problems of surrounding structural components, and design calculations attendant to cockpit conditioning. All of these factors are strenuously affected by the high speeds and altitudes attained with modern combat craft, and would require considerable detail for full discussion, hence this study will be limited to a simple analysis of problems involved in engine and oil cooling and turbojet engine ducting.*

Problem of engine and oil cooling will be considered from the aspect of a propeller drive gas turbine. In engines of this type, there are, in general, three cooling problems—concerned with accessories, engine compartment, and lubricating oil. It should be noted that turbojets have these same problems but to a lesser magnitude, because gearing losses are much smaller.

From the standpoint of entrance losses and aerodynamic cleanness, it is desirable to keep the number of entrances to a minimum. On Ryan Aeronautical Co.'s most advanced turboprop plus-turbojet plane, it was not possible to meet all demands for cooling air in one entrance because of engine configuration. On the turboprop engine, accessories are mounted in the spinner-afterbody, well forward of the cowl lip. It was not possible to duct cooling air forward from the cowl lip to this area, hence an additional entrance scoop was designed for this purpose. From information on generator air requirements a simple scoop was designed to direct cooling air into the generator duct. After leaving the generator, the air circulates through accessory compartment, around engine, and finally out around exhaust stacks.

Situation regarding the oil cooler entrance was much more satisfactory, since it is possible to take all the air required for cooling functions, except as noted above, through this entrance. These air requirements include those for oil cooler, air conditioner heat exchanger, and engine compartment blast cooling. Our first calculations were to determine the air quantities required for these functions.

Let us first consider oil cooler air requirements. Data for this problem include air speed, oil temperature out of cooler to engine, oil flow, heat rejection, air free stream temperature, and altitude. From general thermodynamic relationships, it was determined that maximum cooling requirements occur at sea level. Hence, all calculations were made for this altitude. By specification, maximum cooling requirements were calculated at the "Navy Hot Day" condition of 90 deg F. From airplane speed, ram temperature rise was calculated and added to ambient temperature. This was used as the temperature of air entering the cooler. Temperature consideration is an exceedingly important consideration in high speed aircraft, since velocities are being reached which will make cooling of engines impossible unless allowable temperatures are raised or refrigeration employed.

Continuing with our calculation, using oil flow, oil-out temperature, and heat rejection, the values were computed for oil temperature rise, final oil temperature, average oil temperature, and temperature difference (average oil to entering air). Since the manufacturer's oil cooler performance curves were based on heat rejection in Btu's per min. per 100 deg F temperature difference, an equivalent heat rejection for the actual temperature difference was required. Using this equivalent heat rejection, the performance curves were used to determine required air flow, total pressure, and static pressure drop. These data, in conjunction with air requirements for air conditioner, heat exchanger, and engine compartment cooling, were sufficient to initiate entrance and duct calculations.

From total air quantity as determined, an inlet area was selected on the basis of desired inlet velocity. These preliminary calculations are made without consideration of density changes. Inlet velocity ratio is the ratio between inlet velocity and airplane velocity. From experience, it is known that this should fall between 0.4 and 0.8 to obtain favorable pressure recovery. At this point it is well to emphasize that the entire process is one involving cut-and-dry methods. With reasonable experience, a skilled calculator can obtain the desired results in two or three trials, using the duct analysis table accompanying this article. Although fundamental relationships have been used to establish equations, their evaluation is generally too cumbersome to permit general use.

From the entrance area previously determined, physical outline of the oil cooler, and the desired airplane configuration, the duct was designed. General information given in NACA ARR L4F26, *Design of Power-Plant Installations—Pressure-Loss Characteristics of Duct Components*, established the design criteria. From this duct configuration, areas at various stations were computed and noted in the duct analysis table. Stations used served to divide the duct into components of known characteristics. In this instance the stations were: (1) Free Stream, (2) duct entrance, (3) diffuser exit, (4) cooler face, (5) cooler exit, and (6) duct exit. These stations provided the following components: (1-2) Entrance, (2-3) diffuser, (3-4) branch ducts for engine and heat exchanger, (4-5) cooler, and (5-6) discharge duct and exit.

Free Stream values were determined from known conditions. Since accurate data on propeller ram were not available it was felt reasonable to assume that entrance losses would equal propeller ram, hence calculations could neglect both of these factors. From experience, it was known that entrance and diffuser losses should run about 15%, therefore, the coefficient $\Delta H/q_e$ was assumed at 0.15 and the loss taken in section (2-3). Value q_e is q at the entrance of each component. With these assumptions it was then possible to calculate all values for station (2). Temperature rise (1-2) was assumed to be adiabatic and calculated accordingly. Mass flow, area, and total pressure are known. The procedure then follows a trial-and-error method, where an assumed value is assigned to P and other values calculated. Next, calculated value of P from H minus qF_c is compared with the assumed value. If they are not in agreement, another trial using a different value for P is completed. It is fairly easy to "bracket" the desired value, and with a third trial obtain the desired result. This same procedure was followed in evaluating station (3) values, with the exception of reducing H by the assumed loss.

Station (4) is different from (3) only in that the air quantity is reduced by the flow quantities taken for engine and heat exchanger cooling which introduces variations in all values except A, T, and H. It should be pointed out that this computation is greatly simplified, without introduction of significant errors, by assuming that all processes are isothermal, since static pressure changes are of small magnitude. This assumption, of course, is not made for sections where heat is added, as through the oil cooler. In duct sections of this type, the temperature at cooler exit may be calculated, using a temperature-entropy diagram for air. Static pressure at cooler exit is calculated from the manufacturer's performance data. With these data, the balance of the values can be calculated as before.

Slightly different procedure was followed in calculating conditions at the duct exit. First, it was assumed that external static pressure in the region of the exit would be equal to free stream ambient pressure and that exit losses would be at a minimum if duct static pressure at the exit equalled external static pressure. From these assumptions, values were assigned to T, P, m, and H and calculations were completed to determine the area A.

This entire calculation was repeated for the expected velocity in climb to make sure that critical conditions did not arise. Principally because of the lower ram temperature rise, it was found that substantially the same exit area would suffice. However, since propeller ram is the only means for obtaining ground cooling, it was felt that some means of augmenting this flow

DUCT ANALYSIS TABLE
(Ref NACA ARR L4F26)

Quantity — Each Duct	Symbol	Station					
Temperature, °F abs	T						
Static press., lb./sq ft, abs	P						
Density, slug/cu ft (.000583P/T)	ρ						
Mass flow of air, slugs/sec	m						
Vol. flow of air, cu ft/sec (m/ρ)	Q						
Cross sectional area, sq ft	A						
Velocity, ft/sec (Q/A)	V						
$1/2\rho V^2$, lb/sq ft	q						
Velocity of sound, ft/sec ($49\sqrt{T}$)	a						
Mach number (V/a)	M						
Compressibility factor	F_c						
Impact pressure lb/sq ft	qF_c						
Total pressure, lb/sq ft ($P+qF_c$)	H						
Changes							
Change in total press., lb/sq ft	ΔH						
Change in static press., lb/sq ft	ΔP						
Change in temp., °F	ΔT						
Pressure loss coefficient	$\Delta H/q_e$						

Ducting aspects of Ryan XF2R-1 Dark Shark Fireball. Annular entrance at cowl nose supplies air to GE TG-100 turboprop engine. Large scoop below supplies oil cooler, in manner similar to installation discussed in accompanying article. Fuselage cutout below cockpit provides exit area for TG-100 exhaust. Duct entrance in wing is for aft engine.

* Editor's note: An additional problem—cabin conditioning—was analyzed in detail in "Air Conditioning Turbine-Propelled Aircraft," by H. J. Wood, Feb. and Apr. AVIATION.

should be provided. Hence, a variable area exit flap was provided. This flap will also be effective in improving cooling in flight, if such requirement should prove necessary.

Since all current models of gas turbine engines are cooled internally by excess air introduced by the compressor, problem of engine cooling from the point of view of the airframe manufacturer is relatively simple, but unfortunately, neither easily nor logically solved.

This is because it is not possible to determine heat flow through engine walls and the engine wall temperature, since these values are affected by circulation and temperature of surrounding air. Consequently, it has been necessary to estimate these values on the basis of limited information and experience. Then, the flow requirements can be set up along established thermodynamic principles. This method has been applied, with the refinement of blasting air on critical structural members to insure that their temperatures will not exceed the design limit. From these outlets, the air circulates through the engine compartment to exit openings around the exhaust stacks. It is helpful to observe temperatures at many locations in the engine enclosure during the flight test program. From these data it is possible to modify the cooling system, if this should prove to be necessary.

When we look into the problem of jet engine inlet and discharge ducting, we find that a considerable variety of general, specific test, and calculated data are available. The report referred to previously—NACA ARR L4F26—is "a correlation of what are believed to be the most reliable data available on duct components of aircraft power plant installations." This report enables the thermodynamicist to analyze ducts to determine pressure losses, flow rates, exit area, and drag losses. The process is relatively simple, because it only involves dividing the duct system into components whose characteristics can be determined from tables and charts, and evaluating these characteristics in terms of the airplane speed, altitude, duct dimensions, and shape. Two factors remain which may be difficult—determination of basic configuration of the duct and the calculation of the overall performance of the duct system.

The referenced report provides a number of the usual duct components, sufficient to assist in the evaluation of most systems. Occasionally some duct shapes may not correspond with the configurations presented, but it is believed that satisfactory and conservative compromises have been made. For example, in a certain design analysis the ratio of mass flow to perimeter determined a duct Reynolds number which was larger than the Reynolds number of the available data. However, inspection of the data disclosed that the loss coefficient decreased slightly with increasing Reynolds number. Hence, if data for a smaller Reynolds number are used, the coefficient will be conservative.

Ryan XFR-4 seen here features submerged entry for supplying air to jet engine in aft fuselage. Similar entry is located on other side of craft

Calculation method for duct analysis was described in the discussion of oil cooler ducts, hence we will not discuss it here, except to add that where inlet conditions are known, it is possible to calculate losses between the free stream and the entrance. Greatest difficulty may occur if the airplane under consideration has a tractor propeller. In this case, the calculation of propeller slipstream velocity presents some difficulties which necessitate assumptions, but the possible magnitude of the effects of these assumptions is not sufficient to cause errors of great consequence.

Another factor is introduced in the case of an airplane equipped with a propeller and a jet engine. With this configuration, the propeller drive engine is generally used for continuous operation, supplemented with the jet engine for relatively short periods of maximum performance. When the jet engine is not operating, and with the inlet ducts open, there is sufficient air flow from the ram to windmill the engine. This air flow introduces losses which result in drag, hence it is desirable to close these ducts under this condition. If the inlet ducts are closed by flush-mounted doors at the entrance lip, all losses can be kept at a minimum. However, if the ducts are closed rapidly at idling or windmilling rpm, kinetic energy of the compressor turbine rotor is sufficient to build up a relatively high negative pressure in the ducts. With one engine under consideration, these pressures may reach values as high as −18 in. at rated rpm. Designing the duct structure to withstand these pressures would result in a considerable weight penalty, therefore some means must be provided to positively limit the magnitude of these negative pressures. If this precaution is not taken, a slight error on the part of a pilot can easily result in a major structural failure when the ducts collapse. It appears that some form of a spring-loaded duct door could be used, which would increase the door closing time as a factor of the limiting negative pressure.

We have attempted to describe some of the practical problems which come before the thermodynamicist. It is not merely a matter of knowing a formula and properly applying it. Frequently, new methods must be devised and new approaches undertaken when existing data are not adequate. From this standpoint, it should be apparent that it is extremely important for all individuals engaged in this work to be firmly grounded in basic fundamentals of physics, thermodynamics, and fluid mechanics, and to have the fortitude to pursue likely solutions through many ramifications, with the conviction that desired results will be reached. Final proof is available only when flight test data are obtained and reduced. From this information, we can correlate our assumptions and thus gain valuable experience for application on modifications and new designs.

Morphology and Nomenclature Of Jet Engines*

By F. ZWICKY, *Director of Research, Aerojet Engineering Corp*

One of the top authorities in the field presents a convincing case for adopting a formal system of classifying reaction power plants—an an aid to engineers and in the interests of intellectual and material economy.

Considerations presented here involve a new principle of scientific engineering and its illustration in the field of propulsive power plants. The new principle deals with systematic classification of technical and scientific devices.

Of primary concern in the field of jet propulsion are power plants activated through chemical and nuclear reactions—although measuring instruments, telescopes, signaling apparatus, types of aircraft, and many others, also fall within the same new range. Classification is as follows:

(1) A class of devices is defined by its duty. For instance, propulsive power plants are those which make possible movement of certain craft, such as ships, planes, and rockets through or over certain media such as earth, water, atmosphere, or vacuum.

(2) After a class of devices has been defined, all possible members of this class are arranged in an orderly fashion in a so-called morphological box or manifold, various dimensions of which represent possible ranges of values of significant physical and chemical parameters.

(3) Technical worth of any of the devices is ascertained through a general performance analysis.

Chemical Reaction Jets

Propulsion may be accomplished either through use of long distance forces or of contact forces. The former may be forces of attraction or of repulsion. Propulsion by contact forces occurs when a jet either impinges on the vehicle under consideration or when a jet is emitted or exhausted from this vehicle. The former type will be designated as a negative jet while the latter will be called a positive jet.

The following considerations concern themselves solely with propulsion by means of positive jets. Furthermore, we shall limit ourselves to chemical reactions as the sole source of energy. Use of other sources of energy, such as nuclear reaction, radiation, etc., will not be discussed.

**Editor's Note: Dr. Zwicky originally prepared this material for publication in the Institute of Aeronautical Sciences' "Aeronautical Engineering Review," where it is appearing this month. Because the editors of AVIATION feel there is a great need for standardization of jet propulsion nomenclature, and also because of the interesting possibilities of future developments touched on herein by the author, they have secured the cooperation of Dr. Zwicky and the Institute in giving his paper wider distribution.*

Totality of propulsive power plants activated through positive jets may be analyzed schematically as follows.

Character of Chemical Reactions

Four possibilities are presented.

(1) Chemical reagents or propellents may be self-contained. The device to be propelled carries all chemicals necessary for its activation and operation. Reagents may, for instance, consist of a fuel and an oxidizer, such as alcohol and liquid oxygen, plus water as a coolant if needed.

(2) A device to be propelled through the air may take in this air and use all or part of its oxygen as the oxidizer. The apparatus carries only the fuel.

(3) A device which is to be propelled through or over a body of water may take in this water and use it wholly or partly as one propellant reacting with a water-reactive chemical such as liquid sodium-potassium alloy. The device carries this water reactive chemical only.

(4) A device which is to be propelled through or over the earth may use this earth partly or wholly as one propellant reacting with an earth reactive chemical. The moving vehicle carries with it only this earth-reactive chemical.

For purposes of formal representation, we designate the character of the possible chemical reactions through the matrix $(A_1, A_2, A_3, A_4) = A$ containing four elements as described.

Mechanical Character of Propulsive Devices

There are four possible modes to the principal activating parts of a propulsive power plant, namely: (1) No motion, (2) translatory motion, (3) rotatory motion, and (4) oscillatory motion. Strictly we should consider motion of engine parts and of propellants separately. For simplicity, we shall lump them together or perhaps more properly confine ourselves to motion of permanent mechanical parts of the engine relative to the working fluid. An axial compressor-turbine combination thus falls into category B_3.

Possible modes of mechanical motions are formally represented through the matrix $(B_1, B_2, B_3, B_4) = B$ containing four elements as described.

Character of Thrust Augmentation

Positive jets which cause motion or acceleration of propulsive power plants considered may be due entirely to a fluid flowing through the engine. Or the jet may be reinforced through an alteration of external flow of the surrounding medium. Such an alteration is, for instance, brought about through action of an external propeller or wheel. In this case, we speak of external thrust augmentation. In the former instance we speak of internal thrust augmentation, provided that more external fluid is drawn through the engine than is necessary for the completion of the chemical reaction. In another case in which a stoichiometric ratio of propellants is made use of, we speak of "no thrust augmentation." We therefore must consider the following cases: (1) No thrust augmentation, (2) internal thrust augmentation, and (3) external thrust augmentation. The possible characters of the thrust augmentation are formally represented through the matrix $(C_1, C_2, C_3) = C$ containing three distinct elements as described.

Physical State of Propellants

Three different physical states of

propellants may be distinguished, namely: (1) The gaseous, (2) the liquid, or (3) the solid state. Physical states of the propellants are therefore formally represented through matrix $(D_1, D_2, D_3) = D$ containing three characteristic elements.

Operation of Propulsive Power Plant

Two modes of operation are possible, namely: (1) Continuous operation, or (2) intermittent (pulsating) operation, which may be periodic or more or less periodic. Modes of operation are therefore formally represented through the matrix $(E_1, E_2) = E$ containing two elements E_1, E_2 as described.

Reactivity or Reaction Speed of Propellants

Two pure cases may be distinguished: (1) Propellants may be self-igniting, or (2) propellants are not self-igniting and artificial ignition is necessary.

Reactivity characteristics of propellants are therefore formally represented through the matrix $(F_1, F_2) = F$ containing two elements as described.

A basic propulsive power plant is schematically described through a matrix

$$A_\alpha, B_\beta, C_\gamma, D_\delta, E_\epsilon, F_\zeta,$$

containing one element each of the six elementary matrices A, B, C, D, E, F.

For instance, the aeroresonator with reed valves operating with a liquid fuel which in air is self-igniting can be schematically represented as: $(A_1, B_1, C_2, D_2, E_2, F_1)$— while the hydroturbojet would be represented as: $(A_1, B_1, C_2, D_2, E_1, F_1)$, if a liquid water reactive chemical is used which with water is self-reacting.

In reality, even the above scheme is capable of some refinements. For instance, in order to distinguish between the aeroresonator and the aeropulse, additional distinction of a self-sustaining operation and a not self-sustaining, but artificially timed and forced ignition, must be considered. Neglecting temporarily refinements of this character, the combinations between elements of elementary matrices result in a potential totality of. $4 \times 4 \times 3 \times 3 \times 2 \times 2 = 576$—basic propulsive power plants activated through chemical reactions and resulting positive jets. This totality of engines may be arranged in an orderly manner in a six dimensional morphological "filing cabinet" with dimensions (edges) correspondingly representing significant parameters A, B, etc.

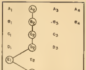


Fig 1 An aeroduct power plant is here depicted and defined by connected circles.

It may, of course, happen that some "drawers" do not contain any reasonable device, if it happens that the specific set of parameters defining this drawer is self contradictory. This might, for instance, be the case for engines characterized by matrices containing elements B_4 (oscillatory motion) and E_1 (continuous operation). In general, a morphological filing cabinet of a given class of devices, such as jet engines, is complete if each drawer contains one device or none. If a drawer contains more than one device, the analysis must be extended so as to introduce enough parameters to define each individual device uniquely.

Since a six dimensional array is hard to depict, a diagram may be used instead to define a specific device (see Fig 1). The propulsive power plant marked by the connected circles is the aeroduct activated by a liquid not-self-igniting fuel (alias ramjet, Lorin tube, or aerothermodynamic duct). All other engines may be diagrammatically depicted or defined in a similar manner.

Some remarks must be made concerning refinements of the above scheme. For instance, numerical value of propellant parameter β may decisively determine the character of the propulsive power plant. This parameter is defined as $\beta = m_{ch}/(m_{ch} + m_e)$ where m_{ch} is the mass of the chemical injected per second and m_e is the mass per second of the external medium involved in the operation. If β is large enough, for instance, in a hydroturbojet, the chemical propellant reacting with the water in the combustion chamber may partly consume this water and in the process evolve enough heat to transform the remaining water into superheated steam. For smaller values of β a part of the water may turn into wet steam, with the result that a gas containing droplets and perhaps solid particles flows through the turbine. For still smaller values of β, water as such may flow through the turbine, containing bubbles of gases which have been generated in the reaction.

Another case of refinement concerns use of axial or centrifugal compressors in turbojets, use of oscillating reed valves or coaxial and cross-axial valves in aeroresonators, and so on. Obviously a great variety of types of engines is possible.

In addition to basic propulsive power plants, combinatory engines must be considered. The reciprocating engine-propeller combination falls into this vast category, since it involves oscillatory (B_4) and rotatory (B_1) motion simultaneously. Another combination is the double-ducted hydroturbojet, which is essentially a combination of an ordinary hydroturbojet and a hydroduct. It may be left to the reader to fathom the tremendous number of

(Turn to page 123)

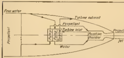


Fig. 2 Diagrammatic rendering of a hypothetical hydroturbojet illustrates Author Zwicky's proposal for standardized power plant drawings

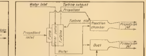


Fig 3 Another example of a criterion drafting style for jet engines, as proposed in this article is depicted in this sketch of an assumed double ducted hydroturbojet

Explosion-Proof Electric Units Seen "Must" for Future Craft

By H. R. CRAGO, Industrial Engineering Div. General Electric Co.

Here are design considerations, backed by extensive test results, on equipment projected to bring greater commercial flying safety without major weight-space requirements.

Electrical systems on modern airplanes are fast approaching in size and diversity of application those of many small industrial plants. The necessity for placing motors and control assemblies in wing and engine nacelle locations, where proximity of gasoline tanks and fuel lines makes explosive gasoline vapors an ever-present possibility, has focused attention on the necessity for explosion-proof equipment meeting the unusual weight and size limitations of aircraft service.

This need was recognized early in the war and some attempt was made to improve explosion-proof characteristics of fuel pump motors. But it was not until the latter part of 1943 that active development work was undertaken to make available to the aircraft industry a line of equipment meeting the same rigid performance requirements as industrial type explosion-proof equipment. There is now available sufficient test data to permit design of explosion-proof airborne electrical equipment at little or no increase in size and weight.

After a thorough investigation of Underwriters Laboratories Class 1 Group D requirements for motors and controls used in hazardous locations, it became obvious that aircraft equipment could not stand size and weight penalties which these regulations would impose. It therefore became necessary to seek a solution to the problem in construction or in principles where size and weight would not be materially increased.

Standard Test

In design of explosion-proof equipment, the problem is not one of preventing entrance of explosive fumes to the equipment but rather one of preventing ignition of surrounding gases when an explosion takes place within the device.

Standard test method is to mount the device in a test chamber filled with an explosive vapor-air mixture, permitting the mixture to flow into the device enclosure. After all air in the enclosure and test chamber has been displaced, the mixture inside the device is ignited by an arc produced by the device or a sparkplug. Failure of the mixture in the test chamber to explode indicates that live flame has not escaped from the test device and that gases that have escaped have been cooled below ignition point of the surrounding mixture. A wide range of vapor air mixtures is always used to insure testing under the most adverse conditions.

Limited Volume Devices

In design of conventional self-cooled aircraft motors and control devices,

Fig 1. Typical explosion-proof electric motor for aircraft use.

necessity for conservation of space and weight tends to reduce the free volume within the enclosure where explosive vapors can accumulate. Also, in these small devices, particularly in the case of motors, normal construction of the enclosure permits it to withstand moderate internal pressure. While maximum explosion pressure produced in an enclosure is dependent upon many factors, such as degree of venting, distribution of free volume with respect to point of ignition, amount of turbulence, etc., all other factors being equal, lower pressures occur with small than with large free volumes. In designing small devices for use in explosive locations, therefore, it is possible to take advantage of the basic structual features to reduce the length of flame paths somewhat below those dictated for commercial explosion proof design, making possible adequate explosion proof construction with little or no weight increase.

In designing explosion-proof motors, attention must be given to the problem of flame paths at bearings and power connections. In general these problems present no particular difficulty. The ball bearing construction normally used for aircraft motors provides adequate flame paths, and a type of power connector providing molded-in prongs and closely dimensioned barrels gives the necessary protection at this point.

In the case of blast-cooled motors and generators, the necessity for cooling air makes the problem of explosion proofing more difficult. At present the use of a continuous air duct system completely segregating the machine from the surrounding explosive ambient appears to be the only practicable solution. The added weight of an exhaust shroud and exhaust duct for most applications is less than the added size and weight necessary to make the machine self cooled.

Tables I and II show test results obtained with varying gas-air mixtures on two motors having widely different free volumes. Table I shows tests on a motor rated 1 hp. intermittent, 7,500 rpm., 24v, having a frame dia. of 2⅞ in. and free volume of 6 cu in.

Table II shows tests on a motor

Table I—Explosion Pressure Test Data on .1-Hp., 7,900-rpm., 24 V. Aircraft Motor

Test No	Percent by Vol. of Gasoline Vapor in Air	Sparkplug Location*	Motor Condition	Explosion Pressure Psi
4	1 8	DE	Running	32
12	2 00	DE	Running	38
36	2 28	DE	Running	25
11	2 51	DE	Running	26
26	2 78	DE	Running	12
21	2 9	DE	Running	8
43	1 62	CE	Running	14
41	2 04	CE	Running	30
8	2 3	CE	Running	32
38	2 45	CE	Running	18
20	3 04	CE	Running	10
9	2 16	DE	Stopped	30
17	2 08	DE	Stopped	26
23	2 69	CE	Stopped	23
30	2 08	CE	Stopped	25
33	1 75	CE	Stopped	16

* DE = Drive end, CE = Commutator end

rator 1.5 hp, intermittent, 7,500-rpm, 24v, with a frame dia. of 5⅛ in and free volume of 65 cu in. Note that the explosion pressure increased to a maximum and then decreased somewhat as the gas air mixture was changed, proving that casual testing with explosive mixtures that are not accurately controlled might not produce the most adverse conditions encountered in service. Table II also shows that appreciably higher pressures were developed with the motor running than occurred at rest, showing that degree of turbulence is one of the factors determining maximum explosive pressure. All tests were made with 90-100 octane gasoline.

Fig 1 shows a representative explosion-proof motor for aircraft service.

Vented Construction

Where larger free volumes are encountered, such as in the larger sizes of motors and control assemblies, the higher explosion pressures developed do not permit the limited flame paths as used on small devices. Here also the added enclosure strength necessary would not be consistent with low weight requirements. For these types of enclosures a vented construction has been found to offer the most practicable solution.

Use of vented enclosures for explosion protection is not new. In 1816 Sir Humphrey Davy discovered that when a piece of metal gauze having certain proportions of free area to wire size is interposed between a flame and an explosive gaseous mixture, the gaseous mixture does not explode. The Davy lamp, used in gaseous mines for many years, is based on this principle. As the gas on the flame side of the gauze is ignited, products of combustion are cooled in passing through the gauze, with the result that when contact is made with the explosive mixture outside the enclosure they are below ignition temperature.

Vented construction has not been generally used for industrial services in the past because of the fragile nature of metal gauze or screen. But with the availability of porous metal plates brought about by the powdered metallurgy processes, it is expected that vented construction will find wider application, particularly where light weight is essential.

Advantages of vented construction are three-fold: First, because the products of combustion due to an explosion are permitted to escape, the design pressure for the enclosure is reduced to a fraction of that which would otherwise be necessary. Second, since the initial pressure wave does not occur, the higher explosive effect due to compression of any remaining explosive gases does not materialize. Third, with the reduced explosion pressure, the hot products of combustion are more easily cooled in passing through the flame paths or enclosure joints and openings, with the result that shorter joint widths can be used.

Tests conducted on the enclosure type illustrated in Fig 2 gave results as shown in Table III. This enclosure design was made originally as a dust-tight case for aircraft service and probably lacks the mechanical rigidity desirable for explosion proof service. With the addition of the venting windows, as shown, it conveniently served as a test model.

The enclosure shown in Fig. 3 represents a later design, providing in addition to the venting area in the front a construction having the necessary rigidity to withstand rough usage and still retain explosion proof characteristics. It is of magnesium die cast construction having a wall thickness of .1 in. and reinforcing at the flanges and power connector entrances. This design was made to house the automatic temperature control system of the Republic RC 2 Rainbow, where all motors and controls located in wings and engine nacelles are explosion proof.

TABLE II—Explosion Pressure Test Data, 1.5-hp., 7,500 Rpm., 24 V. Aircraft Motor

Test No.	Percent by Vol of Gasoline Vapor in Air	Sparkplug Location*	Motor Condition	Explosion Pressure Psi
27	2.38	DE	7,500 rpm	54
12	2.25	DE	7,500 rpm	72
34	1.81	DE	7,500 rpm	81
18	1.8	DE	7,500 rpm	60
5	2.38	CE	7,500 rpm	62
31	2.19	CE	7,500 rpm	66
23	1.9	CE	7,500 rpm	72
24	1.82	CE	7,500 rpm	63
50	2.9	DE	5,200 rpm	42
60	2.78	DE	5,200 rpm	81
43	2.60	DE	5,200 rpm	57
44	2.3	DE	5,200 rpm	63
40	1.81	DE	5,200 rpm	60
54	3.04	CE	5,200 rpm	54
61	2.42	CE	5,200 rpm	54
53	2.04	CE	5,200 rpm	68
76	1.84	CE	5,200 rpm	48
77	1.62	CE	5,200 rpm	42
58	2.79	DE	Stopped	19
45	2.18	DE	Stopped	27
19	1.78	DE	Stopped	21
47	2.22	CE	Stopped	42
54	2.08	CE	Stopped	36
17	1.85	CE	Stopped	36
48	1.70	CE	Stopped	21

* DE = Drive end, CE = Commutator end

Test results tabulated in Table III were obtained with an enclosure having a free volume of 390 cu in. With full venting area effective, maximum explosion pressures were under 5 psi, and no failures resulted over the full range of vapor-air mixtures. Only when the effective venting area was reduced to 10% of normal did failures occur, and even under these conditions the maximum pressure was only 4 psi, which was insufficient to distort the case. Tests made at a pressure equivalent to 50,000-ft. altitude showed no noticeable change in the explosion proof characteristics.

Extended field experience is not yet available on this type construction, but several possible causes of failure have been anticipated and tests made to simulate these adverse conditions. The porous metal plates have been saturated with heavy oil and dust with no apparent adverse effects. The oil and dust were blown out when a slight internal pressure developed. Alternatively filling with oil and dust, and baking, might render the material unsatisfactory for use, but it is believed it should be possible to protect against such conditions by using suitable shields. Saturation of the porous plates with water followed by subjection to freezing temperature did not cause failure of the material.

Design Hazards

In the apparent simplicity of making small devices explosion-proof lies the greatest design hazard. A number of standard aircraft switches, relays, and contactors of conventional dust-tight construction have been tested to determine their acceptability for use in hazardous locations. When explosions did not occur when tested under so-called "representative conditions," there came the erroneous conclusion that the device was adequate for the service.

Frequently the test equipment has been of a rather primitive type, with no provisions for accurate gas analysis, so that results are subject to question. Sufficient publicity has been given these tests to result in a widespread belief that any device of conventional dust-tight construction is adequate for use in hazardous locations.

Fig 3 Typical explosion proof housing for aircraft service.

Fig. 2 Dust tight enclosure with venting plate for explosion proof testing.

Reason for the satisfactory performance of these small devices lies in the limited free volume and partially vented construction resulting from imperfectly fitting covers. The hazard in judging explosion-proof characteristics lies in the inability to determine accurately that all devices of the same design have the same venting ability. Unfortunately there appears to be no satisfactory method for subjecting this type of equipment to explosive conditions more adverse than those actually encountered in service.

In this respect, it is unlike other types of electrical equipment which can be subjected to a high potential test as a check against proper electrical creepages and clearances. In the absence of such a test the only logical approach seems to lie in determining limiting conditions and then applying a factor of safety. Thus, if it is found that flame paths of 4 mil clearance represent marginal operation they should be reduced to 2 mil or less to provide a safety factor. Likewise, if explosion pressures of 50 psi. are developed in test, the enclosure should be designed to withstand some pressure in excess of this value.

In service a piece of explosion-proof equipment remains explosion-proof only when covers are in place and when reasonable precautions are exercised in disconnecting power leads, etc. Prominently displayed information plates calling attention to the nature of the equipment and precautions to be taken in servicing should be a permanent part of each explosion proof device.

From observations regarding probable future aircraft requirements and from tests on various sizes of motors, control devices, and control assemblies, the following conclusions have been drawn:

1. Future aircraft designs, particularly for commercial use, will require more explosion-proof equipment.
2. It is fallacious and unsafe to assume that dust-tight equipment is satisfactory for use in hazardous locations.
3. Most self cooled aircraft motors and small control devices can be made explosion proof by providing adequate flame paths. Such design should incur little or no increase in weight.
4. Control assemblies of relatively large free volume can be made explosion-proof by using properly designed vents. This construction should not increase weight more than a few percent.
5. Availability of porous metal for venting should open a new avenue of approach to design of explosion proof equipment.

Table III—Explosion Pressure Test Data on Vented Type Aircraft Enclosure

Test No.	Percent by Vol. of Gasoline vapor in Air	Percent of Total Venting Area Effective	Sparkplug Location	Explosion Pressure Psi	Results
1	1 61	100%	End	Under 5	No Failure
4	1 87	100%	End	Under 5	No Failure
7	2 2	100%	End	Under 5	No Failure
3	1 78	100%	Side	Under 5	No Failure
11	2 2	100%	Side	Under 5	No Failure
15	2 71	100%	Side	Under 5	No Failure
13	3 01	100%	Side	Under 5	No Failure
25	2 01	10%	Side	4	Failure
26	2 17	10%	Side	3	Failure

PRACTICAL ENGINEERING OF ROTARY WING AIRCRAFT

PART X

By HARRIS S. CAMPBELL, *Consultant to Autogiro Company of America*

Described are various methods and requirements for attachment of blade to hub to permit pitch change, blade flapping, and blade motion in plane of rotation. Included are illustrative examples and derivation of loads.

A ROTOR BLADE mounted for both simultaneous and cyclic pitch change usually should be capable of being freely moved through an angle from approximately minus 5 deg below zero lift pitch angle to approximately 25 deg above zero lift pitch. This allows a cyclic pitch range of ± 10 deg for any average blade setting from autorotational pitch, i e, from approximately 5 deg. above zero lift pitch to 15 deg (maximum lift). This range is, of course, subject to variation in individual designs. In some cases, it may be desirable to reduce mean pitch to zero lift position, with a consequent increase in overall range. In other instances, it may be possible to reduce amount of cyclic pitch change for control purposes. A lesser degree of control movement may be expected in smaller-size craft, which have relatively small moments of inertia and relatively little change in craft C G positions for different loading conditions.

Attachments for Pitch Variation

In rotors having blades individually mounted for pitch variation there are two commonly used methods for blade mounting. First method incorporates bearings capable of carrying thrust and moments developed (Figs 4 and 5). Second method provides bearings for transmitting moments, usually on spread bearings carrying radial loads, and one or more torsionally flexible tension members for carrying thrust loads developed by centrifugal force (Fig 6).

Torsion rod system has certain advantages—chiefly that control forces developed are directly proportional to displacement. Thus, there is a centralizing action tending to return blade to central position. This alone is not an important feature, since when properly designed for chordwise mass distribution, rotor blades have a dynamically stable position to which they tend to return when displaced.

However, torsion rod mounting develops forces during blade cyclic pitch motions which have some beneficial characteristics. Thus, torsion rod moments are usually in the correct sense to help counteract torsional inertia forces and to return blade pitch to neutral, although magnitudes of the two moments are not proportional throughout the cycle.

In designs with blades mounted on thrust bearings, loads transmitted to controls due to thrust bearing friction, are always opposite to direction of motion. Thus, at one portion of cycle of oscillation, friction moment is additive to inertia moment, while at another it is subtractive. So long as friction moments of thrust bearings can be kept small, a thrust bearing mounting may be designed which is entirely satisfactory.

But it should be noted that frictional moments developed by tapered roller or direct roller thrust bearings are considerably greater than for ball thrust types. Also, ball thrust bearings of angular contact type may be used in designs having tandem bearing arrangement as indicated in Fig 5. With tandem bearing mounting, comparatively large centrifugal thrust may be handled without need for excessive diameter of blade root structure to enclose bearings.

In at least one rotor hub design, a tension torsion rod blade mounting has been combined with a thrust bearing. The bearing is inactive until a centrifugal load of approximately 25% greater than normal is developed, when deformation of tension member allows any additional load to be carried by the bearing. With this combination, no frictional loads are transmitted to controls under normal operation. At overspeed conditions, the bearing carries the additional load, thus preventing operating stresses in tension member, which might be in excess of allowable fatigue stress.

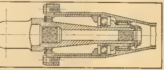


Fig 4. Diagram of blade attachment employing direct ball-thrust bearing.

Flapping and Drag Pivot Stops

In Part IX (Apr AVIATION) under Condition A-1 (normal operating condition), method of calculating average coning angle was given. It is customary to provide upward stops to limit maximum coning angle. These stops should be placed to allow an upward angle of flapping approximately three to four times average coning angle. Angles as much as 25 deg. or more upward coning are permissible. Blade droop stops should allow blades 2 to 4 deg. downward angle from their radial position.

Also (under Condition A-1), method of calculating average or normal lag angle was given. Drag stop is usually positioned to allow at least 5 deg. beyond normal operating position. If rotor operation at full torque but at a reduced rotational speed is contemplated, worst probable operating lag angle should be calculated in the manner shown. Drag stop should have at least 2 deg. clearance beyond maximum rearward operating position. Forward drag pivot stop should be located to permit blade movement at least 2 to 4 deg ahead of true radial position.

Slight excess of blade freedom about flapping and drag hinges is preferable to insufficient angular clearance. Should the blades bottom on either flapping or drag stops under some operational condition during flight, undesirable vibration will be transmitted to the craft.

Strength of Attaching Parts

Blade attaching parts include a blade sleeve, blade terminal on which pitch pivots are mounted, block or extension link connecting drag and flapping pivots, pivot parts, and droop and drag stops. All sections which might be critical should be checked for strength. And it may be necessary to check various sections for more than one condition to determine worst condition.

No attempt will be made to illustrate the complete detail analysis of the various sections. There are given, however, a few methods used to check parts associated with pivots and their bearings. Design of these parts requires more than merely sufficient strength to withstand ultimate loads which may be applied. Sufficient rigidity must be provided to prevent distortion which may result in uneven loading of bearings. Such distortion may cause binding, faulty operation, and premature wear.

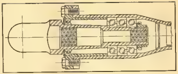


Fig 5. Blade attachment with tandem angular contact bearings.

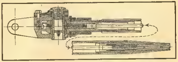


Fig 6. Hafner type torsion rod blade attachment.

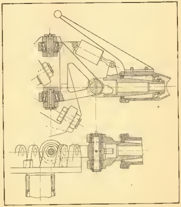


Fig 7. Example of hub and blade connection.

To obtain structure sufficiently stiff for this purpose, it may often be advisable to use overlapping (conservative) assumptions in analysis of adjacent parts. For example, where a pivot pin extends into a fork lug in which a bearing is supported, pin should be designed with a cross section sufficiently strong to carry the ultimate load on the bearing considering the pin as a cantilever member. Lugs which support bearings externally should preferably have a cross section to carry, in addition to tension load, a bending load equivalent to that which would be applied if pin were considered a fixed end beam with lug providing the fixity. This, of course, assumes that leg of the fork of which the lug is a part, is also sufficiently stiff to carry this fixation moment. Examples of such calculations are given below. Bearing mountings designed according to this method have been used in a number of hub designs and have been free from any bearing or structural trouble which might be attributed to lack of stiffness. In many instances, particularly where fork lugs are required to carry cantilever loads, an analysis of actual deflections under maximum loads should be made.

When general arrangement of hub has been decided, a layout should be made showing blade attachment to hub member. This layout will include various forks, lugs, links, stops, housing, and other items, and must be worked out in conjunction with design of the various blade attachment bearings. Size and location of these bearings are a governing factor in design of various associated parts.

Illustrated in Fig 7 is a preliminary layout to study some of the detail blade attachment problems for a rotor having the characteristics previously used as an example. The following calculations are based upon the arrangement of parts and proportions shown in the drawing.*

Drag Pivot Pin

Pin should be checked for loads developed by Conditions A3 and B1. (See Part IX.)

Loads for Condition A-3 —

Ult. centrifugal force = (7,100) (4 0) (1.5) = 42,600 lb.

In Part VIII (Feb AVIATION), a conservative damper operating moment was developed having a value of 400 lb.-ft.

Ult. damper moment = (400) (12) (1.5) (1.5) = 10,800 lb-in.

Damper arm = 3.75 in (Fig 7)

Load at damper = 10,800/3.75 = 2,880 lb.

Maximum combined load at bearing, for condition A3 = 42,600/2 + 2,880/2 = 22,740 lb.

Loads for Condition B1 —

Transverse load at each bearing from maximum starting torque with blade against the drag stop = 63,200/(1 75) (2) = 18,050 lb. (See Fig. 8).

Load at each bearing parallel to blade axis from flapping moment = (31,200)/3.437 = 9,080 lb

Resultant load at bearing =
$\sqrt{18,050^2 + 9,080^2} = 20,100$ lb

Load of 22,740 lb from condition A-3 is slightly more critical

Section AA (see fig 8) —
M_{AA} = (22,740) (.563) = 12,780 lb-in

Neglect thickness of hardened case (.031) and assume remainder of section carries the loads.

Actual o.d. = 1 25 in.
Assumed o.d. = 1 187 in.
i.d. = .875 in.
A = .785 (1 187² − .875²) = .507 sq in
I = .0491 (1 187⁴ − .875⁴) = .0676
f_t = 22,740/.507 = 44,900 psi.
F_{tu} = 75,000 psi. (for steel = 125,000 U T S, Ref ANC-5)
$M.S.$ = (75,000/44,900) − 1 = .67
f_b = M_y/I = (12,780 × .594)/.0676 = 112,200 psi
For D/t = 1 187/.156 = 7.6 and F_{tu} = 125,000 psi.
F_b = 174,000 psi.
$M.S.$ = (174,000/112,200) − 1 = .55

Section BB (see Fig. 9)—To provide a rigid housing for the bearing Section BB is designed to take a fixation moment of half the magnitude of cantilever moment on Section AA (Condition A-3 is critical.)

M_{BB} = 1/2 M_{AA} = 12 780/2 = 6,390 lb-in
Tensile load = 22,740 lb
Area = (.313) (1.062) (2) = .666 sq in.
I_{BB} = $bd^3/12$ = (2) (.313) (1.062)³/12 = .0587 in.⁴

f_t = 22,740/.666 = 34,150 psi
f_b = My/I = (6,390 (.531)/.0587 = 57,900 psi
f_t (max) = 34,150 + 57,900 = 92,050 psi
F_{tu} = 125,000 psi
$M.S.$ = (125,000/92,050) − 1 = .36

The foregoing assumes a rigid construction will be provided for base of fork leg to provide restraint for M_{BB}.

Extension Link at Drag Pin

Section CC—Two sections CC (see Fig. 10) carry shear loads from pin to extension link. Condition B-1 with flapping moment will give worst distribution of shear stress. There will be a triangular distribution of shear stress as indicated in Fig 10. Centroids of shear resistance areas are at distance $h = (2/3) \times 2.25$. Maximum shear stress from moment will be twice average.

Max shear stress = M (2)/(h) A

where A = twice ½ the area of section CC, because there are two sections which carry the shear load

$$f_{st} = \frac{(31,200)(2)}{(.667)(2.25)(2.25)(.313)} = 59,000 \text{ psi.}$$

Stop load at pin from starting moment (Fig 8) = 63,200/1 75 = 36,100 lb

Shear stress at 90 deg. to section CC, from starting moment load of 36,100 lb (see Condition B-1, above, for loads on bearings)

$$f_{st} = \frac{36,100}{(2.25)(.313)(2)} = 25,600 \text{ psi}$$

Equivalent maximum shear stress =
$\sqrt{59,000^2 + 25,600^2}$ = 64,500 psi.
F_{su} = 75,000 psi. (for 125,000 U T S)
$M.S.$ = (75,000/64,500) − 1 = .16.

Bearing Stress—Maximum bearing stress of drag pin in extension link is calculated in generally similar manner to shear stress, since bearing pressure developed by flapping moment will also have a generally triangular distribution.

A_1 = bearing area resisting force F =
$\frac{2.25}{2}(1.25) = 1.40$ sq in

$$f_{br} = \frac{M(2)}{(h)(A_1)} = \frac{(31,200)(2)}{(.857)(2.25)(1.40)} = 29,700 \text{ psi.}$$

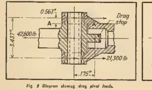


Fig. 8 Diagram showing drag pivot loads.

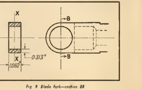


Fig 9 Blade fork—section BB

Bearing pressure from drag stop forces from starting moment,

f_{br} = 36,100/(2 25) (1 25) = 12,800 psi
Max f_b = 29,700 + 12,800 = 42,500 psi.
F_{br} = 175,000 psi.
$M.S.$ = (175,000/42,500) − 1 = 3 10

Flapping Pivot and Lugs

In the hub arrangement shown in Fig 7, it will be observed that in autorotational position—with blade axis radial—centrifugal force of blade is distributed more heavily on rear bearing lugs. In this blade position, loads are applied at 90 deg to flapping axis, resulting in radial loads only. With blade in driven position, 24 deg. 20 min lag, resultant of centrifugal and drag forces intersect flapping axis as indicated at P, Fig 11.

In lag position there is a drag component which is carried by rear bearing A as a thrust load and transferred to supporting lugs there. Thus, both flight conditions A-2 and A-3 should be considered. Also, loads developed at lugs and in extension link from Condition B-1 (torque and flapping) should be calculated. Flapping moment should also be applied without torque with blade in forward position, since this will provide a more severe condition for rear lugs at bearing A.

Condition A-2—Apply ultimate centrifugal force (C_F) at normal lag angle, 24 deg 20 min, together with damper moment and ultimate vertical load, and calculate horizontal and vertical loads at lug points A and B, and drag load applied to A.

Ult. C_F = (4.5) (7,100) = 32,000 lb
Ult. V = (4 5) (2,100)/3 = 3,150 lb.
Damper Moment M = 10,800 lb.-in.

Components at P—

B = (32,000) cos 24 deg 20 min = 29,000 lb
D = (32,000) sin 24 deg. 20 min. = 13,100 lb.
V = 3,150 lb.
M = 10,800 lb-in. (either direction).

At A—

$$H_A = \frac{2.55}{6.625}(29,000) + \frac{10,800}{6.625} = 11,150 + 1,630 = 12,780 \text{ lb}$$

$$V_A = \frac{2.55}{6.625}(3,150) = 1,210 \text{ lb}$$

D_A = 13,100 lb.

At B—

$$H_B = \frac{4.075}{6.625}(29,000) + \frac{10,800}{6.625} = 17,850 + 1,630 = 19,480 \text{ lb}$$

$$V_B = \frac{4.075}{6.625}(3,150) = 1,940 \text{ lb}$$

D_B = 0

Condition A-3—Apply centrifugal load in radial position through B, and apply vertical load at B.

Ult. C_F = (6 0) (7,100) = 42,600 lb
(limit L.F. for twice normal rpm = 4.0)

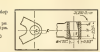


Fig 10 Extension block—section CC

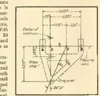


Fig. 11. Flight loads at flapping lugs.

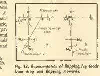


Fig. 12. Representation of flapping lug loads from drag and flapping moments.

Ult. V = (6 0) (2,100)/3 = 4,200 lb.
(for one blade)
Damper Moment M = 10,800 lb-in

At A—

$$H_A = \frac{(5.375)(42,600)}{6.625} + \frac{10,800}{6.625} = 34,550 + 1,630 = 36,180 \text{ lb}$$

V_A = (5.375) (4,200)/6 625 = 3,410 lb
D_A = 0

At B—

$$H_B = \frac{(1.25)(42,600)}{6.625} + \frac{10,800}{6.625} = 8,050 + 1,630 = 9,680 \text{ lb}$$

V_B = (1 25) (4,200)/6.625 = 700 lb
D_B = 0

Condition B-1—With ultimate torque applied, blade will be in rear position against lag stop (30-deg lag angle) as in Fig 12a.

Ult. torque = T = 63,200 lb-in.
Ult flapping moment =
M_f = 31,200 lb-in.
Moment in radial plane =
M_h = 31,200 cos 30 deg
= 27,000 lb.-in.

Moment in drag plane =
M_d = 31,200 sin 30 deg
= 15,600 lb-in
Reaction at R = 27,000/1.875 =
14,400 lb

Drag load will be inertia developed at centroid of inertia of blade. Because blade is tapered, centroid of inertia will be inboard of 2/3 point. Assume centroid at .55R = (.55) (40 25)/2 = 11 05 ft = 132.5 in.

At A—

H_A = 63,200/6 625 = 9,550 lb

$$V_A = \frac{(14,400)(5.375)}{6.625} - \frac{15,600}{6.625} = 11,700 - 2,350 = 9,350 \text{ lb}$$

D_A = 63,200/132 5 = 477 lb

At B—

H_B = 63,200/6 625 = 9,550 lb

$$V_B = \frac{(14,400)(1.25)}{6.625} + \frac{15,600}{6.625} = 2,720 + 2,350 = 5,070 \text{ lb.}$$

D_B = 0

Condition B-1a—Obtain loads applied to lugs at A for most forwardly position of blade (5 deg. ahead of radial against forward drag stop) for flapping moment only. (See Fig. 12b)

M_h = (31,200) cos 5 deg = 31,000 lb-in.
M_d = (31,200) sin 5 deg = 2,710 lb-in
Reaction at R = 31,000/1.875 = 16,600 lb in

At A—

H_A = 0
V_A = (16,600) (5 375)/6 625
= 13,450 + 330 = 13,780 lb
D_A = 0

A summary of lug loads for the above design conditions is given below.

Table I—Summary of Lug Loads At A and B (Fig. 11)

Conditions & Components		A	B
A-2	H	12,780	19,480
	V	1,210	1,940
	D	13,100	0
A-3	H	36,180	9,680
	V	3,410	700
	D	0	0
B-1	H	9,550	9,550
	V	6,350	6,070
	D	477	0
B-1a	H	0	Not Critical
	V	13,750	
	D	0	

Reference to summary of loads will show that lugs at point A should be checked for stresses developed for both Conditions A-2 and A 3. Lugs at point B should be designed from loads for Condition A-2 and checked for Condition B-1.

These loads are used in detail design of extension block structure between flapping and drag pivots.

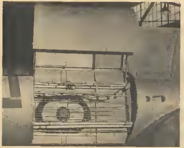
Design Highlights of Northrop Pioneer

Unusual accessibility built into airfreighter as aid to ground men. Also included is handy entrance hatch.

Long expanse of Northrop Pioneer's leading edge in up position impressively indicates designed-in access ease of new cargo plane, providing unhampered working area forward of front spar →

This portion of Pioneer wing with leading edge raised reveals handy placement of flap and aileron cables. Wiring leads to outer air temperature pickup also landing and navigation lights. To left of dark oval (which is sealant around edges of fuel tank access panel) is stowed wing jack pad. To use, jack pad is removed and bolted to six-hole fitting directly below. →

This exposed working area, located next to outer engine nacelle, reveals power plant electric and hydraulic lines. From top to bottom: Four hydraulic lines; vacuum line; fire extinguisher line, conduit shielding ignition cables, thermocouple electric leads; cables to oil shut-off, mixture, carburetor air, throttle, and prop pitch controls, fuel lines from tanks to selector valves, and spoiler cable. Such planned accessibility also helps speed tasks of workers assembling aircraft and installing equipment on line ↓



Another neat design trick is this swing-down panel fitted with a convenient step, beneath forward portion of craft. Originally intended only for prototype Pioneer, hatch gives ready entrance to forward cabin area and flight compartment, and may be retained as an emergency exit. ↓

Speedy Combat Servicing Designed Into Republic Thunderjet

Newest and speediest fighter craft to go into squadron service embodies maintenance lessons learned during war.

FIG. 1

Fig. 1 Republic engineers strove to cut time necessary for ground personnel to get at important P-84 components. How well they succeeded is indicated in this view of Thunderjet fore fuselage (with GE J-35 turbojet in place). Encircled around fuselage perimeter are three of four attachment points for mating fore and aft fuselage sections. Also indicated are engine mounting braces. Note how further accessibility is available through numerous small panels in fuselage. ("Aviation" staff photos by E. J. Bulban)

FIG. 2

Fig. 2 Large, quickly detachable panel makes possible easy access to interior of whole upper nose section, containing vital combat equipment such as craft's six 50-cal. guns and their ammunition containers. Note component's sturdy construction.

FIG. 3

Fig. 3. Depicted in extended position, this double-skin structure serves a two-fold purpose. Primarily it is P-84's under-fuselage dive brake, but ground crews use it as an access panel for getting at some of J-35 turbojet accessories.

Martin Proving Six-Jet XB-48

Large high-speed craft is fitted with novel undercarriage which utilizes tandem main wheels under fuselage and small outrigger wheels for maintaining taxiing stability.

Most powerful of the late crop of all jet bombers to join the AAF is the big new Martin XB 48, powered by six powerful GE turbojets grouped in threes beneath each wing. Although no performance data have yet been released, indications point to a top speed, at favorable altitude, approaching the transonic.

A really noteworthy innovation is the unusual landing gear fitted to the new bomber—showing how ingenuity was applied by Martin engineers in overcoming a serious design problem. The very thin high-speed airfoil designed by the company did not allow for sufficient space to house conventional large main wheels when retracted. Hence the XB-48 has a special arrangement—two main wheels arranged tandem fashion under the fuselage, with the front wheel located behind the cockpit and rear wheel just behind the trailing edge, plus a small wheel beneath each outer engine nacelle to give stability during taxiing, this latter gear retracting into shallow wells.

Entirely of metal construction, the XB-48 has an empty weight of 58,500 lb., span of 108 ft. 4 in., length 85 ft 9 in., height 27 ft. 6 in., and total wing area of 1,300 sq. ft. A streamlined canopy houses pilot and co-pilot. A radar-controlled gun turret is located behind the single tall rudder.

We are told that just 14 months elapsed from the time the company initiated engineering work on the craft until the day it was rolled from its hanger to begin ground tests.

This profile of new Martin XB-48 points up craft's high degree of streamlining. Particularly interesting is unique landing gear arrangement, with two tandem main wheels in fuselage, and small twin wheels located beneath outer engine nacelles. This type landing gear was extensively tested by Martin before application here. Note new AAF star-and-bars insignia.

View from topside clearly shows mounting of XB-48's six GE turbojets, which probably are J-35s (TG-180s) each generating over 4,000 lb thrust at sea level. These power plants are expected to give craft a top speed of 600-mph-plus. Long range is said to be another of plane's assets. This is first six jet conventional-design plane to be built.

Neat lines of new Cessna 195 belie craft's size. Model 190 is practically identical, except that it mounts lower powered engine. Both craft gross 3,350 lb. and have ranges of over 700 mi., with cruising speeds of over 160-165 mph. Takeoff and landing characteristics are stated to be very good, to enable operations at small fields. Cantilever high wing affords good sightseeing view.

New Personal Four-Placers Announced by Cessna

Radial-powered high-wing craft with fixed gear made in two models, one with 240-hp. Continental and other with 300-hp. Jacobs, both engines having constant speed props.

Aimed at the business executive market, the latest aircraft to be offered by Cessna Aircraft Co., Wichita, Kan., are the four place 190 and 195—both of which already have received their NC ratings. Although no word is yet available regarding production, prices (f.o.b. factory) are given us as $12,750 for the 190 and $13,750 for the 195.

Both craft are of all metal construction and are stated to be virtually identical throughout, except for power plant installations, the 190 having a 240-hp Continental, and the 195 being fitted with a 300-hp Jacobs. These radials are fitted with two-blade Hamilton Standard Constant Speed props as standard equipment. Top speed for the 190 is given as over 170 mph., with cruising speed (7,000 ft. on 70% power) at over 160, rate of climb 1,050 fpm., and service ceiling 16,000 ft. The 195 has top speed of over 180 mph., cruising (7,000 ft at 70% power) over 165 mph., 1,200-fpm climb, and 18,300 ft service ceiling. These performances were arrived at with both models grossing 3,350 lb. Other figures common to both craft are range (700 mi.), fuel capacity (70 gal.), and luggage allowance (200 lb.).

Except for length—27 ft. 2 in. for the 190, and 27 ft 4 in. for the 195—all other dimensions are the same. They include: Span 36 ft. 2 in., height 7 ft. 2 in., cabin height 47 in., cabin length 104 in., door 43x31 in., and luggage door 25x22 in.

Landing gear, constructed of chrome vanadium steel, is fixed and uses the same strut flexing principle to absorb landing shocks which has been used on the company's two seaters. Other features include retractable step, throw over control column, and Dynafocal engine suspension. Standard equipment includes instrument flight panel, two way radio with loudspeaker, cabin heater, and landing lights. We are told that the cabin has been especially planned for roominess. Supplied are seat cushions constructed with No Sag springs and foam rubber. Ample leg room is provided between front and rear seat, the latter being reported large enough for three. Front seats are adjustable forward or backward as much as 14 in. Luggage compartment is also accessible from the back seat.

Latest Private Wings

Aeronca, Thorp, and Puget Pacific reveal new two- and four-place craft for personal owners.

Aeronca Scout is new side-by-side trainer selling for $2,475, and having 80% of its parts interchangeable with Champion and Chum. New craft has 65-hp. Continental, burning 4.4 gph. at cruising, and fuel capacity is 15 gal. Designed for hard usage incurred during student training plane is equipped with dual wheels, adjustable seat, ash-trays, and two glove or map compartments. Wide auto type doors are fitted to each side.

Flight-test view of Thorp Skyscooter (Company President John Thorp is at the controls) shows compact little side-by-sider to have pleasing lines. Powered by 65 hp Lycoming top speed is given at 115 mph., while cruising is set at 101 and landing at 45. Note use of skin beading on wing and horizontal tail surfaces, also large fillet at trailing edge of wing root. This fairing is said to obviate any tendency of premature root stall.

Initial test flights of this Pudget Pacific Wheelair have been announced as successful by its Tacoma, Wash., builder. All-metal four-seater is spin proof and stall-resistant. Top speed is given as 140 mph while range is set at 600 mi on 50-gal fuel capacity. Nylon tanks are located in wing sections on either side of fuselage. A second prototype is to be built and both craft are slated for exhaustive tests for CAA certification.

Canadian DH Readies Beaver Light Freighter

Small four-placer, of all-metal construction, is work-horse craft for operating in rough country.

A FOUR-SEAT LIGHT FREIGHTER especially adaptable to operations in the Canadian north country is being prepared for early flights by deHavilland Aircraft of Toronto. This plane is designated as the DHC-2 Beaver.

High-wing and semi cantilever in layout, the Beaver is of all metal construction, with gross weight of 4,400-4,600 lb. It is capable of operating on wheels, floats, or skis. One version is powered by a P&W R-985 Wasp Jr of 450 bhp for takeoff, while another is planned to take the DH Gipsy Queen engine, as soon as it becomes available. A three-blade DH reversible pitch prop is installed. Edo 4580 type floats are specified.

The cabin is fitted with four separate seats, with the pilot's seat being permanent but adjustable. Gross cubic capacity is given as 144 cu. ft., with an additional 8 cu. ft. available in the emergency locker. Rear doors are flush with the floor and are said to be wide enough to permit loading of a 45-gal fuel drum on its side. In addition there is a door on either side of the cockpit. Hatches are provided in the rear wall of the cabin and beneath the fuselage to enable loading of long pieces of freight. Total fuel capacity is stated to be 80 gal in three belly-located tanks, suspended from the floor structure and removable for servicing. Fillers are provided in an accessible position on the fuselage sides, so that refueling may be accomplished without need for ladders or climbing over the wings.

Controls are of the dual type, with Y control column and throw-over wheel. Flaps are mechanically operated, and an electric starter is fitted as standard equipment. A 24v electrical system is provided, and an engine driven 450w. generator with suitable regulator is installed. Batteries are provided in the rear of the fuselage in a readily removable tray accessible through the fuselage side. Standard instruments are given as follows: Pioneer airspeed indicator, turn and bank, directional gyro, inclinometer, Pioneer altimeter, tachometer, manifold pressure gage, oil pressure, oil temperature, fuel quantity, fuel pressure, ammeter, and compass.

Specifications and Data

(Figures in parentheses are for landplane)

Span	48 ft.
Length	32 ft. 4 in. (30 ft. 3 in.)
Height	10 ft. 10 in. (8 ft. 7 in.)
Top speed (5,000 ft.)	150 mph. (163 mph.)
Cruising speed (5,000 ft.)	135 mph. (140 mph.)
Economical cruising speed (5,000 ft.)	123 mph. (133 mph.)
Rate of climb (takeoff)	1,160 fpm. (1,425 fpm.)
Absolute ceiling (approximate)	18,000 ft. (18,500 ft.)
Takeoff time (zero wind)	22 sec. (11 sec.)
Landing speed (40-deg. flaps)	55 mph. (55 mph.)
Baggage	702 lb. (506 lb.)
Payload	1,212 lb. (1,016 lb.)
Disposable load	1,366 lb. (1,742 lb.)
Empty weight	2,634 lb. (2,858 lb.)
Gross weight	4,600 lb. (4,600 lb.)
Engine	450-hp. P & W Wasp Jr
Propeller	deHavilland

Artist's conception of new Canadian DH Beaver cargo carrier fitted with Edo floats and P&W Wasp Jr of 450 hp. According to company sources, craft is expected to be flying in next month. Top speed with floats is given as 150 mph carrying 1,212 lb payload, with top range at 580 mi. Easy loading and servicing has been planned from start of craft's design, implemented by operators' suggestions.

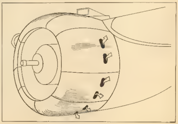
High-Utility Plus Comfort Designed Into Stratocruiser Seat

INGENIOUS ARM-REST CONTROL PANEL seen here is feature of Boeing designed seat for company's Stratocruiser Installation indicates when seat is occupied, signals stewardess, allows for reclining, incorporates ... receiver, supports lunch tray, shows seat number, and carries switch for reading light Perfected by special section of Boeing Engineering, which studied data on measurements of several thousand men and women, seat has contoured back and lock joint for quick straightening when changing from day version to berth position Foam rubber construction added to lateral springs and canvas provides equal comfort for light or heavy occupant (90 300 lb) Extent of detail refinement is indicated by experimental test in which it was found that air blast against fuselage produced small but persistent vibration of about 0003-in in seats placed in plane of propeller To overcome this condition, a live rubber suspension device was introduced, which, though eliminating vibration, caused oscillation as occupant shifted weight. Further study resulted in elimination of oscillation via weight-transferral mechanism For seat removal, turn of screwdriver releases "Wedgit" fasteners at each support

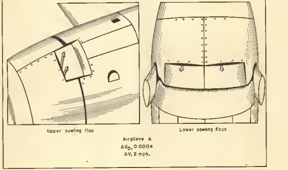
Searching Drag Studies Check Speed Impeders

PART II

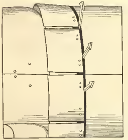
Continuing this analysis, additional details are presented concerning relation of cowling design factors and drag.



This method of controlling airflow quantity to remedy unsatisfactory engine cooling in climb condition was found to cause excessive drag. Eight holes—each with area of 12.5 sq in.—were cut in periphery of cowling just behind cylinder baffles Subsequent tests indicated that cooling problem was not remedied for climb condition, also flow disturbances caused by holes resulted in drag coefficient increase of .0041 for cowlings of two engines—corresponding to decrease in craft high speed of about 13 mph.

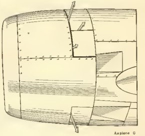


On three installations seen here, drag increases were measured when doped-tape seals were removed from gaps at hinge lines of closed cowling flaps. Arrows show points of leakage that disturbed external flow and resulted in drag increase More complete sealing or directing of airflow backward would tend to eliminate this drag increment.



Cowling flap closed

Airplane B
ΔC_D, 0.0005
ΔV, 3 mph.



Airplane C
ΔC_D, 0.0005
ΔV, 3 mph

Powered Rotary Vixen File Speeds Wing Skin Installation

• A faster, better method for trimming wing skin has been inaugurated in Ryan Aeronautical's final assembly department

Difficult task in construction of wing assemblies is fitting of metal skins—placed over contour of airfoil and riveted at trailing edge, then built to leading edge. When final section is laid down, there is an overlap on front spar, which must be trimmed to allow sufficient room on spar to attach leading edge section Overlap is present because skin sections are cut slightly large to allow for dimensional differences

Old method for trimming edge was to leave it unriveted while shearing off excess metal by hand, then hand filing ragged edge—a slow and unsatisfactory process

New device for the job is rotary vixen file mounted in vertical position in hand tool utilizing a guide table which fits over spar edge. Operation is via compressed air, and file can be adjusted to cut at various distances back from spar edge. Resultant trim is uniform and smooth, saving many man-hours

Seen in accompanying photos are Ryan's Glen L Humphrey (who suggested method) applying the tool, and closeup of the device.

Four-Alloy Aging Cycle Boosts Production Efficiency

• Elimination of production delays caused by necessity of heat treating various aluminum alloys for different time periods, has been successfully achieved at Glenn L. Martin Co by utilization of a time cycle found satisfactory for at least four different alloys—53S, Alclad 14S, R-301, and 61S—and conforming to government specifications

With old method, the four alloys were aged at same temperature—350 deg F—but at different time periods, 14S and R-301 being aged for 6 hr, 53S and 61S for 8 hr This difference in time delayed rush jobs or necessitated use of engine mount furnace, or rivet or wood shop furnace for heat treating some of these alloys

As suggested by Martin's J Edwin Burkhardt, the four alloys are all aged together at 350 deg for 8 hr, or at 340 deg for 10 hr—saving at least 40 hr of furnace time each week, and eliminating need for using other furnaces, thus obviating delay in heat treatment of rivets and mounts And there is a small direct saving of additional loading, unloading, and transportation of alloys to different furnaces. Storage space is saved, since it is unnecessary to rack up an accumulation of alloys to await heat treatment, and benefits are derived through more efficient shop planning

Alternate 10-hr. treatment at 340 deg permits aging operation to be conducted during interval between shop's 2nd and 1st shifts—2nd shift putting material in furnace, heat running while no one is working, and day shift taking material out

In accompanying photo, Mr. Burkhardt is seen checking load of diversified aluminum alloy aircraft members ready to go into furnace

New Simplicity in Servos Improves Automatic Control

By JACK ANDRESEN, Kollsman Instrument Division, Square D Co., Elmhurst, N. Y.

Operating on the principle of following a contact on a meter that indicates the governing quantity, new mechanism has application in many instruments—such as air mileage indicators, altimeter actuated transponders, and automatic calibrators for radiosonde barometers.

As a means of minimizing the number and complexity of instruments and controls over which the pilot must maintain direct supervision, there has been wide recognition and adoption of methods of automatic activation of these units on commercial and military aircraft.

The automatic control generally requires some sensing element to measure a signal, combined with a means of converting this signal into mechanical action to operate a control formerly in the hands of the pilot. The means of signal conversion into mechanical force differ in complexity, depending upon how quickly it is necessary to correct variations of the controlled quantity, and upon the strength of the signal coming from the sensing element.

For systems where the output of the sensing element translates to a weak mechanical motion (such as in a sensitive altimeter, airspeed indicator, or milliammeter) and where precise followup of position is required, an extremely simple system has been devised.

An electrical contact is put on the pointer, diaphragm, or other mechanical indicating part to be followed. Then, on a motor driven element designed to follow the first mentioned part there is a mating contact. When these contacts touch, the motor which drives the follower is made to run in a direction to separate them, and when they are separated, the motor runs to close them. Thus the follower is continually hunting back and forth, with the contacts touching and separating. To minimize this hunting, which is usually objectionable from standpoints of mechanical wear and performance, two factors are important: (1) The motor should have the highest possible torque-inertia ratio, and (2) there should be minimum backlash in the gearing and linkage to the follower contact. Where possible backlash should be reduced to zero by spring loading the mechanism. Where the step-down ratio from motor to contact is not strictly dictated by power output requirements, an optimum value can be determined by trial. On a well designed system, amplitude of hunting at the contacts may be of the order of 0.0005 in., although much larger values are tolerable on systems.

To assure accuracy and long life in following small motions, it is necessary to keep contact current to a minimum. Also it is desirable to have a minimum of electronic components in the system. To these ends, the motor reversing circuit shown in Fig. 1 was conceived. Grid bias voltage on the thyratron need be only about 6v. Thus with 1-megohm grid resistors, contact current is only 6 microamp. With such small current and with silver or platinum alloy contacts, wear or pitting is barely detectable after 500 hr, and operation is unimpaired for several times this period. Provisions must be made, however, to keep the contacts free from dirt or excessive moisture. Because of the low contact voltage, the circuit is unaffected by altitudes exceeding 80,000 ft.

Referring to Fig. 1, operation of reversing the low-inertia two-phase induction motor is as follows. Capacitor C_1 is chosen so as to make current in Phase 1 substantially in phase with the supply. Capacitor C_2 is smaller than C_1, so that when the thyratron is not conducting, current in Phase 2 of the motor is leading in phase with respect to the supply and hence with respect to Phase 1. When the contacts are closed, causing the thyratron to conduct, the low resistance of the thyratron shunts C_2, with the result that the circuit of Phase 2 has substantially the inductive impedance of the motor and hence draws a lagging current with respect to line voltage or to current in Phase 1. This phase shift, from about 60 deg. leading to about 60 deg. lagging, effects an instantaneous reversal of the motor with about 83% of full torque obtainable on a regular two-phase supply. For aircraft applications, motors most frequently used are small, two-phase squirrel cage or drag cup types of servomotors.

For an airport traffic control system now under development, it was necessary to provide a barometric altimeter with sufficient torque to operate a multiple rotary switch. Substitution of a contact for an altimeter pointer and a small motor with

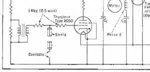


Fig. 1. Circuit diagram of contact-follower motor control.

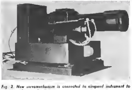


Fig. 2. New servomechanism is connected to airspeed instrument to give air mileage indication.

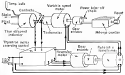


Fig. 3. Seen here is schematic representation of air mileage indicator shown in Fig. 2.

reduction gears to a mating contact, did the trick. An output shaft was provided with a useful torque of 500 in.-oz. One revolution of the shaft is equivalent to 5,000 ft. There is no measurable loss of accuracy from that of the altimeter mechanism. Hunting amounts to ± 10 ft., which is undiscernible at the output shaft and has a frequency of hunt of about 5 cycles per second. The contact on the mechanism is on a shaft of the altimeter which makes one revolution every 12,000 ft., and it is at a radius of 0.75 in. from the axis of this shaft.

Fig. 2 is a photo of an airmileage unit which uses a contact follow-up. And Fig. 3 is a schematic of the same device. In this system a contacting arm replaces the pointer of the true airspeed indicator. The mating contact is carried by the pointer shaft of a motor-driven magnetic-drag tachometer whose scale is linear with rpm. If the contacts are open, the control motor is made to run in such a direction that the output of the connected rotatable transformer is increased. This action in turn increases the speed of the tachometer motor and causes the tachometer contact to advance until it touches the airspeed contact. Once the contact is made, the control motor reverses, opening the contacts and the cycle is repeated. Thus the tachometer contact follows the airspeed contact. Since both calibrations are linear, speed of the tachometer motor is proportional to airspeed, and hence the total revolutions of the motor are proportional to air mileage. By choice of correct gear ratio, the counter reads directly in miles.

In this case, the period of hunting of the contact system is 2 or 3 sec. per cycle. Hunting is symmetrical above and below the correct value, therefore errors are compensating.

In addition to the counter, the motor can be used to drive an odograph (ground course plotter) or the usual air position indicator. Within limits of the motor power and rotatable transformer output, addition or changes in load will not affect the accuracy of the integrated mileage, since this depends only on the calibrations of true airspeed indicator and tachometer.

A rather novel application of this principle is used for automatically calibrating radiosonde pressure elements. As shown in Fig. 4, a long micrometer screw, tipped by a contact, is made to follow the surface of mercury in a manometer (center). The manometer measures pressure in one of the adjoining chambers full of test radiosondes, while the reversing motor controlled by the mercury contact operates the carriage on a table (not shown) carrying 16 solenoid actuated pens over calibration charts. Thus 16 pens are moved over their respective charts exactly in accordance with pressure in the test chamber.

Through a pair of synchros, the motor also drives the micrometer screw in the right-hand manometer column and associated dial indicator reading directly in millimeters. Pressure element of the radiosondes being tested consists of a contact operated by an aneroid diaphragm which slides over a commutator resembling a piano keyboard. As each contact is made, a relay circuit makes the solenoid pen print a dot on the chart. By these means a complete graph of the performance of each radiosonde element is automatically plotted.

To compensate for ambient barometric changes, a second contact follow-up employing a motor driven micrometer directly contacting a stack of aneroid diaphragms is used to raise or lower the whole manometer.

Given the low inertia motor and the reversing circuit, engineers are finding answers to numerous automatic control problems. Use of a functional or empirically shaped cam on the motor-driven shaft cooperating with a light contact arm on a sensitive measuring instrument provides the basis for a computing system. Automatic measuring or gaging of parts and raw materials, as well as measurements of strain in structures, are easily accomplished by the contact follow-up principle.

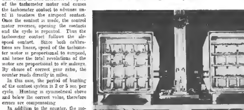
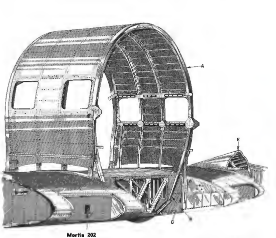
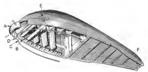


Fig. 4. Radiosonde barometers are automatically calibrated using new servomechanism.

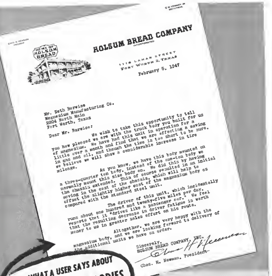


Martin 202

Fuselage splice to center wing section. (A) Center fuselage assembly, (B) wing front spar, (C) fuselage-to-spar splice members, (D) exhaust duct for center wing anti-icing air (leading edge panel is removable) and (E) engine nacelle.



Inboard view of wing tip assembly. (A) Detachable panel for effecting tip removal, (B) attachment lugs for mating with corresponding lugs on wing, (C) threading wire for lugs, (D) lockwire, (E) electrical disconnect, and (F) tip trailing edge portion, containing slots for exhausting anti-icing air.


HOLSUM BREAD COMPANY
INCORPORATED
1110 LAMAR STREET
FORT WORTH 2, TEXAS

February 5, 1947

Mr. Seth Berwise
Magnesium Manufacturing Co.
2204 North Main
Fort Worth, Texas

Dear Mr. Berwise:

We wish to take this opportunity to tell you how pleased we are with the truck body you built for us of magnesium. We have had this unit in operation for a little over a month and find that we are effecting a saving in gas and oil, and though the time is too short to be sure, we believe we will show a considerable increase in tire mileage.

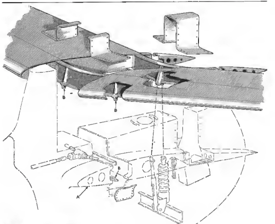
As you know, we have this body mounted on a three-quarter ton body, instead of the one-ton body we normally mount this size body on. We did this by having the chassis extended. This of course resulted in an initial saving in the cost of the chassis, which will help to offset the slightly higher cost of the magnesium body as compared with the standard steel unit.

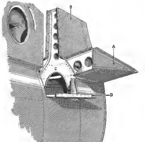
The driver of this unit, which incidentally runs about one hundred and twenty-five miles per day, reports that it "drives like a passenger car." We feel that the resulting decrease in driver fatigue is worth money to us in greater sales effort on his route.

Altogether, we are very happy with the magnesium body, and we are looking forward to delivery of the additional units we have on order.

Sincerely,
HOLSUM BREAD COMPANY, INC.

Chas. H. Newman, President

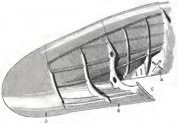




Martin 202

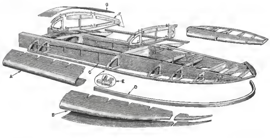
Adjustable horizontal stabilizer is connected to flap torque tube system, via mechanical linkage to vary angle of incidence with flap deflection. At (A) is seen stabilizer fixed stub section, (B) front spar hinge point. Rear spar fitting is for attachment to actuating linkage motivated by T-shaped rod assembly.

Empennage details shown here include (A) Horizontal stabilizer stub section opposite elevator, (B) fixed section beneath rudder (C) opening for stabilizer rear spar (covered by hat-shaped fairing), and (D) stabilizer rear spar and elevator torque rod panel.



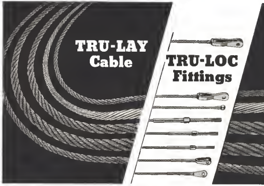
Martin 202

Inner view, left side fuselage-to-center wing fillet: (A) Reinforcing rib adjacent to fuselage (belly) flap, (B) fuselage bottom aft of fuselage flap, (C) area occupied by fuselage flap in retracted position, and (D) fillet aft portion



Dart GC

Exposed and partially exploded view of two-place personal craft's wing. Construction is of wood. Shown at (A) is notched one-piece top-and-bottom wooden leading edge covering, (B) two-piece leading edge covering, (C) built-up portion of spar, (D) leading edge strip, (E) detail of leading edge joint, (F) through capstrips, and (G) wing walk.



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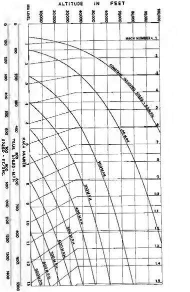


Courtesy Engineering Dept. Douglas Aircraft Co

Why South Africa Rates A-1 for Export

By **RAYMOND L. HOADLEY,** *Financial Editor, "Aviation"*

AIRMINDED SOUTH AFRICA presents one of the brightest spots, for the United States, in the personal plane export picture.

That sounds like a pretty broad statement, doesn't it? But we can back it up with many facts and figures from all the market angles, as well as through the sound judgment of some of our most experienced foreign traders, both in and out of the aircraft field

In the first place, the Union of South Africa is an exporter's dream—a wealthy young country where the importer may purchase any product from the U. S. in any amount he sees fit—without government import or exchange permits required. The trade is unfettered by any artificial restraints. What other markets fit this description? You can name them on the fingers of one hand

South Africa is probably in the soundest monetary health of any major area in the world She has a budget surplus Business and individual taxes have been cut There is no external debt (it was $392,000,000 in 1939), and there is only a small internal debt So, there's little wonder that in proportion to its size and population South Africa is the best customer in the world for our manufactured goods And we are sending more manufactured goods there today than any other nation.

It is not surprising, then, that our total exports to South Africa have jumped from $79,000,000 in 1939 to $227,000,000 in 1946, an increase of close to 300% During this same period, British exports increased about 100% And while Britain furnished 43% of South African imports to our 20% in 1939, these two great foreign trade competitors are running neck-and-neck today, with each supplying around 35%

South Africa comprises a single economic unit consisting of the Union of South Africa, South West Africa, Northern Rhodesia, and Southern Rhodesia The area is about two and one-half times the size of New York State It has a population of about 5,000,000 enjoying a standard of living comparable to the average American Then there are some 12,000,000 natives with a comparatively low standard of living

Income taxes on a $5,000 salary comes to around $250 annually and only jumps to $500 on a $10,000 income South Africa has not half the inflation that troubles most of the world, so there is a very comfortable margin left on most incomes to spend on imported goods

South Africa has an advantage for us not held by any other market within the British Empire Although included within the sterling area, this is a theoretical rather than an actual detriment to our trade Actually, the Union can freely secure dollar exchange and is able to ship gold directly to the United States.

In fact, it is one of the few nations that has a steady source of foreign exchange The reason for this is that South Africa produces 50% of the world's gold That enables her to buy where she pleases without regard to allocations or quotas or special permission of the sterling area managers — the considerations that hamstring the import activities of most other countries attached to the sterling bloc.

Her gold mines produce $400,000,000 worth of gold for export, an amount four to five times the 1946 import excess in her merchandise trade with us The Union has exports, including gold, of $650,000,000, against imports of $500,000,000 This leaves a very comfortable margin of $150,000,000 to acquire other goods in various export fields. It is understandable that some of our biggest manufacturers now consider South Africa our second best export market and that 200 prominent American foreign traders voted it a "promising" field Besides gold, South Africa has coal, diamonds, and a big sheep production And she is self sufficient in food

With trade unrestrained and monetary health excellent, airminded Union offers a "good now, better later" market for U. S. private aircraft. And adjacent South West Africa and the Rhodesias augment the opportunities. No import duties are levied on American-made aircraft products; and "making none of their own, they stand ready to take ours."

As for aviation aspects, it has been said that South Africa has more landing strips in proportion to population than any other country in the world The government has provided subsidies to its towns for maintaining these strips, and many of the smaller towns depend almost entirely on air transportation Climatic conditions are excellent throughout the year.

Airports and subsidiary fields capable of handling the traffic of the postwar area are available or building in all parts of the area Air traffic has shown a phenomenal rise since 1939, with planes flying regularly between the principal cities. The Department of Civil Aviation of South Africa is active and responsible Certification by CAA of all aviation material sent to that country is required, as well as flight tests before licenses are issued

There is no aircraft production in the South African area, and there is no duty on the importation of American-made aircraft products On the other hand, a large number of United States surplus personal aircraft have found their way, at extremely low prices, into South Africa from the Middle East. Although this is a temporary condition, it has tended to cut new aircraft sales.

South Africa is off the beaten path. But some of our plane manufacturers figure that the richest business rewards are often picked in remote areas R. W. Addington, assistant export manager for Luscombe Airplane Corp, recently embarked on a sales tour to South Africa, planning his trip to arrive in Durban with two 1947 Silvaires shipped there by boat This is claimed to be the first time a lightplane maker has sent a representative to tour South Africa in a small plane.

W. B St. John, Piper general sales

manager, at last report had a total of 31 active Piper dealers in South Africa According to St John, shipments of more than 90 planes, plus additional orders, indicate a tremendous growth in private flying there.

The Stinson division of Consolidated Vultee Aircraft Corp., recognizing the importance of having a first class distributor in South Africa, sent an executive there last year to examine all potential firms A successful merchandising firm having distribution outlets throughout the area was appointed, and an aviation department was set up with service facilities and flight personnel to handle the Stinson products Early this spring some 20 Voyagers had been shipped, and many more Voyagers and Flying Station Wagons probably will be sent there this year

Mr McGivney reports that Voyagers are being used by industrial firms, ranchers, and agriculturalists as a means of transporting personnel and supplies, as well as for reviewing the progress of construction and farming. In addition, the Stinsons are used for primary and advanced flight training and by aerial taxi firms

It was found that customers selected the Voyager because of its ability to get in and out of very short areas and its ruggedness, resulting in low cost operation and maintenance. South Africa generally is situated on a plateau of about 5,000 ft., and it has a high temperature, reaching 115 deg F, practically the year round. Under these conditions, the Voyagers —boasting short takeoff performance and excellent stability—are stated to be particularly adapted to the needs of operators in South Africa.

There is no valid reason why South Africa should be treated differently from any other importing country, according to her leading importers Trading methods there conform in every important respect with common commercial practice elsewhere. Its marketing plan is no different fundamentally from that which operates in California, for instance.

As consumer values have never been even roughly market-researched, it is impossible to estimate the relative buying powers of the different races All that can be said is that the "whites" in town and country have a standard of living far higher than that of Europeans, while the millions of "blacks" buy on average only the barest necessities of life.

Approximately 80% of the goods imported into South Africa are sold there by distributors representing their factories. Most of these manufacturers' representatives handle products on an exclusive basis That is, the manufacturer agrees to supply nobody else with the product, and the distributor agrees to represent only that particular manufacturer's product in that type of article. By this manner of operation, the manufacturer usually insures himself of maximum coverage in the South African field. Often this means coverage for Southwest Africa, Nyasaland, Mozambique, and the Rhodesias, as well as the Union itself.

Good distributors have outlets throughout these areas. However, no appointment of a manufacturer's representative should be made on a favorable financial report alone, important as this may be Such factors as trade repute, goodwill, and degree of service are of greater significance in a young commercial country, such as South Africa

American manufacturers who visit this area are usually amazed at the almost total lack of specialization in the export and import trade One of the largest and most progressive importers sells tractors, electric light plants, radios, machine tools, etc.

In fact the distributor of Stinson planes also is the largest dealer in General Motors cars, Lionel trains, and Club aluminum pots and pans.

To sum up, South Africa is a country with plenty of money and an active demand for American products. Because it ranks so high as a purchaser of our products, it's easy to forget that in many respects it's still a comparatively small market.

Yet it is a market with a future South Africans talk of growing to a population of 20,000,000 whites Their gold-mining industry has been built up, over 50 yrs., to a capitalization of \$3,000,000,000 Now they tell you that, as a result of new prospecting, South Africa faces a new gold mining expansion equal to that \$3,000,000,000, and that this expansion isn't going to take 50 yrs—that it probably will take only 15 to 20

So South Africa in the next couple of decades may want another \$3,000,000,000 of equipment, capital goods, and transportation Today there is one automobile in South Africa for every five persons, a concentration on motor cars almost as heavy as in the United States. Who knows but what the concentration on planes may grow the same way one of these days in that speculative, young nation which already ranks as one of our best export markets

"Maguire has his own ideas about necessary refrigeration for high speed flight!"

How Many Fares Make a Profit?

By A CANADIAN BUSH PILOT

"When load becomes payload" can be exactly determined through use of the scrupulous power-space-density analysis... And whether the rate charged the passenger is "right" is also thus revealed, as well as the precise dollars-and-cents status of the cargo compartment.

A PRIME QUESTION of air transport operators is: "How many passengers are required on board in order to break even for every mile flown?" And it is certainly worthwhile to investigate, particularly since there have been claims that fares per passenger mile are too low. This article will indicate how one may arrive at an answer to the prime question, and accordingly find whether fares are—or are not—too low.

One might say that this view of fares only achieved significance since the lowering of airmail subsidy rates. In any event, it behooves the operator to determine the status of the fares. It appears that, in the past, the passenger cabin derived unwarranted support from the cargo compartment. Of course, in a general way this condition has been recognized for some years—hence we've had the practice of subsidizing passenger air transport operations through payment of high airmail rates.

Point at issue is to find out for sure if aircraft have yet been designed that can become self supporting or profitable from fares that the public will pay. The crux of the passenger business is the degree of public patronage measured in terms of aircraft seat occupancy.

Cost of first-class transport craft is such that high occupancy ratios are a growing imperative, as a natural outcome of lowered mail rates. We cannot expect this necessity to lessen with time, either, since specialized airmail planes are being developed which will rob many passenger routes of a much-needed income.

Our attack on the question will again employ the realistic power, space, and density factors as a means of analysis. Use of this p-s-d method in making aircraft operating cost studies has already been outlined and demonstrated in two earlier articles.*

In any attempt to determine the responsibility of the passenger business in terms of its proper share of the cost of operating, it is necessary to know just what the exact cost of the passenger business is. Having figured this for a given aircraft, it is then an easy step to determine the factor of seating capacity of the aircraft and weigh it against the cost-burden which the passenger business should support.

We will now detail the p-s-d procedure whereby an operator may check upon the capabilities of his current fleet. It is assumed that the expense factors are distributed according to the CAB listing. It is also assumed that the total number of cruising hp-hr. used for any given period can be determined, and that the figures covering total operating expenses for the same period are likewise available.

The expenses may be divided into two main sections—mechanical airborne cost, and the remainder costs. The well established companies, having large fleets and steady schedule obligations, can consider certain specific factors—depreciation of all flight equipment, direct labor, and material for overhaul and repairs—as coming within the scope of the first section (mechanical airborne cost). If the air-

WORK TABLE

Employing Costs Per Cruising Horsepower-Hour

1. Cruise power of aircraft
2. Mechanical airborne cost — aircraft, less passenger accommodation
3. Mechanical airborne cost — passenger cabin, fixtures, etc.
4. Ground cost — all remaining costs, except passenger service and passenger traffic departments
5. Ground cost attributable to passenger business
6. Total cubic capacity of aircraft assigned to payload
7. Cubic capacity of all space used for passenger accommodation and facilities including space used for free baggage
8. Cruising speed mph
9. Passenger seating capacity
10. Space per passenger in cu ft. [(7)/(9)]
11. Current passenger mile fare rate
12. Profit rate in cents per passenger mile
13. Passenger cost per passenger mile equals [(11) — (12)]
14. Number of passengers required on board to meet (13) [Computation as below]
15. Cost per passenger-mile equals

$$\left[\frac{(2)\times(1)}{(8)\times(6)}+\frac{(3)\times(1)}{(8)\times(7)}+\frac{(4)\times(1)}{(8)\times(6)}+\frac{(5)\times(1)}{(8)\times(7)}\right]\ (10)$$

16. Permissible number of cu ft. space per passenger equals [(13) (15)]×(10)

Computation for (14): Number of passengers required on board to meet (13) equals (7)/(16)

* "Transport Cost Precision Via P-S-D Approach," page 163, Dec. '46 AVIATION, and "Pinpointing Costs Per Passenger-Mile," page 97, May '47 AVIATION.

SAMPLE CALCULATIONS

To demonstrate use of work table, arbitrary values are applied and worked below. It is emphasized by author that these random figures do not represent any specific company operation or aircraft type.

1. 3,600 hp	8. 300 mph
2. \$0.04	9. 30
3. \$0.01	10. 100 cu. ft.
4. \$0.08	11. \$0.05
5. \$0.02	12. \$0.00455 (10%)
6. 3,600 cu. ft.	13. \$0.04545
7. 3,000 cu. ft.	14. 34 (Computed below)

15. Cost per passenger-mile equals

$$\left[\frac{.04 \times 3{,}600}{300 \times 3{,}600} + \frac{.01 \times 3{,}600}{300 \times 3{,}000} + \frac{.08 \times 3{,}600}{300 \times 3{,}600} + \frac{.02 \times 3{,}600}{300 \times 3{,}000}\right] 100$$

equals (.000266 + .00008 + .000133 + .00004) 100
equals .000519 × 100
equals .0519, or \$0.0519

16. Permissible number of cu. ft. per passenger equals

$$\frac{.04545}{.0519} \times 100$$

equals 88 cu. ft. per passenger

Computation for (14): Passengers required to reduce the cost to \$0.04545 equals (7)/(15) — that is, 34

craft and its power are depreciated on different bases, the first section may then be subdivided accordingly, to provide these two headings: Aircraft costs, less power, and power expense.

In order to get at the cost of the passenger business, it is first necessary to obtain the specific cost of passenger accommodation by breaking down the mechanical cost of operating the aircraft (less power), and in like manner to get the cost of operating the passenger service and passenger traffic departments by breaking down the aforementioned remainder costs.

With each of these factors reduced to a figure of cost per cruising hp.-hr., the work table (accompanying this article) can be employed. The aircraft may now be treated as a simple cargo transport with passenger accommodation added separately.

Referring to the work table, it will be noted that computation is required to complete Item 14. Cost per passenger-mile may be found by applying the pertinent values (derived from statements of operating expenses and operating statistics) to the equation in Item 15. The operator is now in a position to compare the result of the Item 15 equation with the value for Item 13 (as shown in Item 18). Whereupon, he may determine the number of passengers his aircraft must accommodate to meet the cost target in Item 14 (as carried out in the concluding line of the work table).

This information also reveals how much support the passenger cabin requires from the cargo section of the multiple-load aircraft.

In order to clarify the procedure suggested, we have included sample calculations in which random values are worked in demonstration. Referring to these calculations, it is obvious that the demand in (14) cannot be met by a 30-passenger aircraft. The extra four passengers required represent a cost unearned by the cabin, equal to 4 x (13), or \$0.1818 per aircraft-mile. This is equal to the revenue from approximately 600 lb. of express at current rates.

Fortunately, no operator owns the hypothetical aircraft we have here under cost investigation. In event some operator has a plane even remotely like it, he should pay close attention to his cargo revenue, since 100% occupancy will not make him financially carefree.

If we assume that the average passenger and free baggage occupies 100 cu. ft. of space, and the combined weight is 200 lb., then the density rating is 2 lb. per cu. ft. This accommodation is being provided for \$0.05 per passenger-mile—which is less than it costs. Conclusion is unavoidable that passengers cannot be carried profitably at density ratings of 2 lb.

Logical procedure, therefore, seems to be to determine the cost of the passenger cu. ft.-mi. for your aircraft, add the necessary amount for profit, multiply this amount by the number of cu. ft. you require per passenger, and then compare with the government-approved rate per passenger-mile. Solution of your problem from that point depends upon the character of your route.

Enterprising Service Has No Limits

By SCHOLER BANGS, *Pacific Coast Editor, "Aviation"*

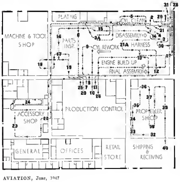
Foreseeing the benefits of integrated aviation service and supply facilities, Pacific Airmotive sets a pattern for drawing on a wealth of trade—ranging from work for domestic and foreign major airlines to the individual plane owner.

NEW EVIDENCE of the growing business potential in aviation recently appeared at Burbank, Cal On an 18-acre site adjoining Lockheed Air Terminal, Pacific Airmotive Corp.—world's largest aviation supply and service organization—has opened a $2,000,000 home office and factory headquarters, and settled down to making itself a notable factor in the industry

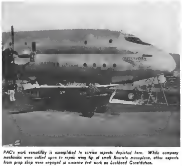
This new Burbank plant—proving ground for repair and overhaul techniques designed to capture a substantial segment of domestic and foreign business—is the focal point of a rapidly developed system of bases located at Anchorage, Alaska; Oakland, Cal ; Kansas City, Mo.; and Linden, N. J., this last base now being under development as a project similar to the Burbank operation And as an extension of these base facilities, PAC now maintains supply and engine exchange services at Glendale, San Diego, and Fresno, Cal ; Phoenix, Ariz., and Seattle, Wash

Armed with strong buying power (California's aggressive Union Oil Co owns 53% of PAC stock, and Bank of America recently displayed its confidence in PAC's future by extending $6,000,000 revolving credit unsecured loan), the company is staking its future on long-range large-volume business produced by highly specialized services

In effect, the new Burbank structure —embracing 112,000 sq ft. of shops, retail store space, and offices—and an adjoining 60,000 sq ft. warehouse present a showcase of three vital aviation services brought together to make a major industry



Layout of work-routing in Pacific Airmotive's new Burbank plant (1) Engine receiving, (2) steam cleaning booth, (3) disassembly, and (3A) small engine disassembly Cylinder flow: (4) Cyl. removal, (5) cleaning, sandblasting, seedblasting, and metallizing, (6) visual inspection, (7) to production control, (8) to rework and repair, (9) honing and grinding, (10) return to production control, and (11) to engine assembly At (12) and (13) large- and small-engine build up, respectively. Engine parts flow: (14) Parts removal, (15) cleaning, (16) Magnaflux and Zyglo inspection, (17) general inspection, (18) modification, (19) painting, and (20) to production control. Accessory flow (21) Removal, (21A) ignition harness overhaul, (22) accessory shop (production control), (23) overhaul (24) carburetor and accessory testing, and (25) to production control. Other engine details (26) Parts and accessories to build-up (12 and 13), (27) pre-oiling before check run at test cell, (28) to cell and return, (29) solvent spray booth, (30) check and service before shipping, and (31) shipping. Propeller flow (32) Disassembly and cleaning, (33) Magnaflux inspection, (34) hub, dome, valve, and shank overhaul (35) inspection, (36) blade balancing, sanding and polishing (37) blade paint booth (38) blade boot repair, (39) propeller assembly balancing and feathering test, and (40) shipping



PAC's work versatility is exemplified in service aspects depicted here. While company mechanics were called upon to repair wing tip of small Reorwin monoplane, other experts from prop shop were engaged in airscrew test work on Lockheed Constitution.

Chief PAC profit producers are its merchandising division (acting as distributor for 300 manufacturers of close to half a million items of aircraft equipment) and service division for overhaul, repair, and modification of aircraft engines and accessories, propellers, instruments, and radios. Comparatively small, but important to foreign customers, is a third division—equipment manufacturing—producing special test equipment and tools. This activity primarily serves the company's own shop requirements, but also functions for selling its products to foreign airlines for maintenance and overhaul of American-manufactured engines and accessories.

In close relationship with its service and merchandising facilities, PAC is developing, for its Burbank activity and other major bases, a potentially profitable engine exchange program that is not unlike the exchange plan of the automobile industry. Currently, small airlines and fixed base operators are the best customers for this service, but company officials foresee that it will be sought by an increasing number of personal aircraft owners. Operation of constant-flow overhaul lines for transport aircraft engines makes possible the rebuilding of exchange engines at a minimum cost for man hours and materials.

PAC's engine exchange plan—first to be attempted by an aircraft service and supply organization—had for its genesis the basic philosophy influencing all phases of the company's growth.

Briefly stated, the organization's overall objective is to eliminate the airplane operator's need for a spare equipment stockpile and shop maintenance facilities that are excessively costly unless fully utilized on an around-the-clock basis.

Major sales argument of PAC has been that it is able to relieve the plane operator, charter plane owner, cargo contractor, and major certificated airline of costly spare parts and shop equipment inventories.

The point made—and with telling effect—is that this will release capital funds for profitable expansion of operations, and that by mass production methods PAC can duplicate the operator's engine and accessory maintenance functions at lower cost.

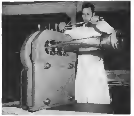
To cargo, executive, and personal plane owners, PAC presents, in its engine exchange plan, fixed prices for all sizes of power plants, thus enabling the operator to estimate accurately his engine time costs. Also emphasized, is that it is unnecessary to ground a plane for an average of three weeks for engine overhaul, since PAC is able to effect engine exchange and have the craft in service in a matter of hours. Also, the owner gains assurance, supported by PAC's elaborate inspection service and business responsibility, that the exchange engine has been modified to conform to manufacturer's latest engineering change orders.

Sales arguments such as these, supported by cost figures accumulated during the company's 20-yr gradual growth, have been dominant in PAC's attainment of a strong position with the certificated air transport industry.

When Pres. Earl Herring won financial support from Union Oil Co. in '45, the present guiding policy of relieving the operator of his shop and parts inventory burden began to be asserted. In its single hangar overhaul base at Lockheed Air Terminal, PAC had accumulated both equipment and shop know-how for large scale engine overhaul. It had gained the confidence of an increasing number of airlines in handling overflow business from crowded maintenance bases, and war-

Finishing assembly touches are applied to this PAC-overhauled 2,000-hp.-plus P&W engine. Meticulous care is evident in cleanliness.

Small engines, too, such as this 65-hp. Continental, pass through PAC's extensive shop activity.



This blade straightener was designed by PAC engineers to simplify repair of all-metal props. Machine will undergo thorough test before being made available to customers.

time orders from military agencies—such as NATS and Consairway—provided additional knowledge of intricacies and economies of the constant-flow overhaul line

Armed with this experience the company expanded overhaul facilities at Oakland and Anchorage, extended its holdings to another base at Kansas City, and only recently invaded the eastern market by lease of hangars for installation of large shops at Linden.

It began to cite to airlines that it stood ready with a nationwide system to free them of costly maintenance investments. Touring the nation, General Service Manager Stan Wilson knocked at the doors of airline executives and told his story. He knew—and almost to the dollar in every instance—what each airline was spending in man-hours and inventory costs for engine overhaul. And he guaranteed that PAC could do the same job for fewer man-hours, and possibly better.

When he found an airline about to spend $75,000 to $90,000 for a soundproof engine test cell he argued that PAC possessed four modern cells at Burbank, two at Oakland, one each at Anchorage and Kansas City, and soon would have four in operation at Linden. Built to a standard design, these cost only $50,000 per unit, and each was able to handle up to 60 engines per month. He pointed out that not only would the airline be faced with a physical investment of close to $100,000 in building its own installation, but also it was unlikely its test stand would have more than 50% utilization—20-30 engines per month.

It simply was smart business, Wilson showed, for the airline to save itself the cost of the test equipment, and to economize still further by closing its engine overhaul shop to let PAC do the work. And as a final argument, backed by buying power of PAC's bank credit, Wilson would offer to take over the airline's entire spare parts inventory.

Wilson's salesmanship has been effective, and today PAC boasts that it handles the engine overhaul business, either entirely or on an overflow basis, of no less than 30 air carriers, domestic and foreign.

Currently, PAC is overhauling, for airlines, an average of 168 twin row engines per month, and with the Linden plant in operation will double that number in a short time, Wilson believes. Panam, on the West Coast, is an outstanding major customer, contracting for overhaul of 50 engines a month from its Pacific Alaska div. Overhaul of 25 P&W Wasp Majors puts PAC in a position to bid strongly for the business of domestic and foreign carriers with respect to Boeing Stratocruisers and other Wasp powered craft coming up.

In the Burbank plant, where 97,000 sq. ft. is occupied by shop operations, and at other overhaul bases, engine lines represent a striking cross-section of domestic and foreign transport industry. Overhaul tags show ownership of engines by these domestic airlines: Western, Pan American, United, American, Empire, West Coast, Challenger, Pacific Northern, and Alaska. On the same overhaul lines are found engines of such foreign customers as Air France, Philippine Air Lines, Peruvian International, FAMA, China National Aviation Corp., Panagra, Panair do Brasil, KLM, KNILM, and Far East Air Transport.

To a surprising degree PAC bids for and gets engine overhaul orders from owners of obsolete craft. Probably no other overhaul and maintenance organization possesses a comparable accumulation of specialized tooling for the overhaul of aircraft long out of manufacture.

A Look at the Shop

Both for inducement of "good housekeeping" and functional value, dynamic coloring has been applied liberally throughout the shop area. Moving parts of machinery are painted yellow. Splashes of orange indicate electric controls. Fire fighting equipment conforms to the national code and is painted red. Piping and conduits are painted variously as an aid to plant maintenance crews and trouble shooters, following a color code devised by PAC.

While shop equipment is conventional (with exception of specialized tooling and test stands designed and built by PAC) notable care is apparent in placement and use of overhaul machinery. Two electric powered travel cranes have hoists of the air-lift type, giving extreme sensitivity of control in delicate mating of engine assemblies. Similarly, in the choice of a hand pull crane to move cleaning tanks, the air-lift type was selected to eliminate fire hazards that might be encountered with electric hoists.

Throughout the engine parts cleaning process, progressive station-to-station delivery is via trolley conveyor to reduce parts handling normally required by use of carts and dollies. Not until all parts have been cleaned and delivered to a production control room is an engine scheduled for assembly under close supervision of inspectors.

Unique feature of the Burbank shop is its reclamation of hydrocarbon cleaning solvent—consumed at rate of 6,000 gal. per month at 25 cleaning stations. To avoid handling problems attendant with gathering solvent in portable collection tanks, a drainage system is installed leading from each cleaning station to a plant collecting tank and solvent filtering system. Once cleaned, the solvent is fed into an underfloor pressure manifold and returned by delivery pipes to the cleaning booths.

Cleanliness of the plant is marked. In the engine tear-down section, running water in a grate-covered drainage ditch carries oil and grease to a grease dump. Added floor protection is given by pans and paper placed under engines to catch final drippings, the paper being burned in an incinerator following soiling. All possible floor obstructions that might catch trash and dirt have been eliminated, and at work benches semi-rubber ribbed matting is used on the floor, in preference to wooden slats, the matting being cleaned easily without moving. All partitions

and walls are hard finished for ease of cleaning

Adjacent light fixtures in the fluorescent lighting system are wired on separate phases to eliminate flickering and stroboscopic effects. In serving the light installation, normal 120 cycle a.c. has been increased to 360 cycles to avoid eye fatigue. Use of straight mercury arc was avoided because of irritating effect. Only in one high bay is mercury arc lighting used—combination of one mercury arc and one incandescent fixture side-by-side to obtain a desired 35 foot-candles having an approximately white-light color.

While some smaller engine overhaul shops have considered air conditioning and close temperature control an asset in precision work, PAC engineers who designed the Burbank plant anticipate no production difficulties in the use of a simple ventilating system. Their experience has shown that cleanliness of the shop area, and liberal use of solvent wash down throughout the overhaul process, makes dust control by air conditioning unnecessary.

Considering that in full production the new plant will handle 200 engines per month, space given to this phase of the business represents unusual use of flow-line engineering techniques—shown in the chart on page 89.

While PAC's considerable investment in the Burbank plant is qualified by the number of airlines entering the Los Angeles area, also the proximity of plane manufacturers (Lockheed, Consolidated Vultee, Northrop, Douglas, and North American) whose entire overhaul is done by the plant, the location is also strategically important in the courting of foreign business.

With this and the Linden location, the company has ready access to two of the nation's major harbors, and can invite foreign air carriers to take advantage of low shipping rates to obtain a quality of engine overhaul unduplicated at foreign air bases.

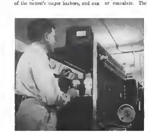
The company's appreciation of foreign business potential is demonstrated also by the close attention given to export merchandising. As an aid to foreign buyers it now has in operation an export department and a system under which the representative of a foreign government or airline, upon contacting the company, is assigned a company export representative who expedites all of his purchasing business. The visitor is given undivided attention by the PAC representative assigned to him. Hotel space and transportation are arranged, and if necessary, contact with the visitor's embassy or consulate. The escort guides the visitor through the various company departments and introduces him to engineers and merchandising experts trained in meeting his buying requirements.

If the foreign airline representative discloses plans to construct one or several overhaul bases, PAC engineers are prepared to suggest shop layout plans with scale models of American machinery designed to meet his requirements. The visitor is indoctrinated in PAC's engine overhaul price and delivery schedules as well as its engine exchange plan, and he is also acquainted with the details of the company's facilities for work on propellers, accessories, and instruments.

It is probable that the foreign buyer will find in PAC's merchandise display room and warehouse a majority of items he might have expected to seek in a long shopping tour of a number of markets. To such a buyer PAC offers a clinching appeal of requiring only one credit arrangement to cover his entire needs. The customer need only draw one order for one lot of goods which is shipped to his country through one customs office from one place. Further, if the required or comparable equipment is not found on PAC stock shelves, it will be obtained by the company and made a part of the customer's blanket order.

It is to the credit of Earl Herring and his associates, in developing the largest enterprise of its kind in the world, that they should foresee the need of major airlines as well as individual plane owners and then put into practical demonstration the economies of pooled resources of service and supply.

In important behind-the-scenes activity, this company design engineer makes detailed graphic analysis of proposed test equipment.



Electrical inspector checks PAC-made magneto test equipment—valuable contribution to company's high quality service.


Mobile servicer—converted Jeep—makes speedy rounds in gassing craft at Rhode Island State Airport.

Jeep Refueler Speedy and Economical

Small vehicle—fitted out by gas concessionnaire—is successfully adopted for rush-period servicing at busy airport.

THROUGH CONVERSION of a war born Jeep into a fuel truck with 160-gal. capacity, servicing for peak traffic periods is successfully handled at Rhode Island State Airport (Hillsgrove). The vehicle was fitted out by James A Wilcox, operator of the Socony Vacuum gas concession at the field

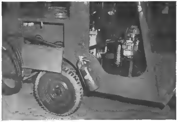
In addition to fuel, the truck carries all standard equipment required by CAA for vehicles used in servicing air liners—strainers, micron filter, water separators, check valves, air release, and small ladder

Before adapting the Jeep, Operator Wilcox used two standard trucks for servicing—each with capacity of 1,575 gal—but these machines proved too large and unwieldy, occasionally delaying service

On a recent busy Sunday, when the control tower recorded 1,566 takeoffs and landings in 8 hr., 1,700 gal of fuel were sold—800 gal. being pumped from the Jeep and only 900 from the two big trucks combined. And it was felt that without the little servicer the demand could not have been met With three planes per minute using the runway, all craft were able to be serviced, the Jeep gassing three planes while a big truck serviced only one. In the course of delivering the 800 gal, the Jeep burned only 3½ gal. in servicing 120 planes.

Meter on the Jeep is located just inside right door, where it can easily be seen by attendant standing at wing or fuselage with the gas nozzle.

The operator has been so encouraged by the experiment and its reception that he is preparing to convert Jeeps, on a business basis, for airport use


Right side and interior view of converted vehicle. Fuel gage is positioned for easy observation from gassing station on plane.

Sturdy Mobile Rack Holds 3 Props, 6 Domes

■ This propeller shop storage rack—for three blade Hydromatics and two blade constant speed airscrews—was designed and built by prop department personnel at Southwest Airmotive.

Rack is 8 ft square at bottom, is supported at base on 3 x 10s along two sides and double 2 x 4s along other sides, and is mounted on four 8-in. wheels for mobility. Center height from base is 9 ft, and extending to top from each of four corners are 2 x 6s. Vertical supports are two rows of 2 x 6s, 17 in. apart from front to rear of rack, and 14 in. apart from side to side.

Seven two-blade propellers can be hung horizontally, each on two 1-in. pipes, 16" long, secured to pair of inclining 3 x 4s. Pipes are covered with rubber tubing to protect blades.

Six three-blade propellers can be suspended between grooved, topmost horizontal timbers. To facilitate prop removal, rear timber is comprised of removable blocks, sitting on spacer pieces which, in turn, rest on angle-iron clips with through-bolts to hold the unit together. When these blocks are removed, propellers can easily be swung up, out, and down with sling and hoist.

Six propeller domes may be stored at bottom of rack (behind two-blade section) in individual wood lockers. (Tom W. Collins photo)

Hydraulic Test Rig Saves System Check-Time

■ With use of this mobile hydraulic test apparatus, check time man-hours have been cut to one-third of those formerly required at Southwest Airmotive's Dallas base.

Designed by Shop Chief George Kelley and built at the base, unit gives results similar to those obtained with engine run-up. It is used for checking hydraulic and vacuum systems, and is particularly advantageous in discovering leaks.

Inside of metal cabinet are hydraulic and vacuum pumps for connection to outlets on craft firewall via Aeroquip high pressure hose—two for hydraulic lines, one for vacuum—as seen below. Top of cabinet is equipped with pressure and suction gages, suction regulator, bypass valve control (seen at Mr. Kelley's right hand), and emergency stop and start buttons (at left hand).

Power for device is led in via 100 ft. extension cord plugged into 220v., 3-phase hangar outlet. (Tom W. Collins photos)

Main-Gear Ground Lock Affords One-Hand Application

■ Designed by Douglas Aircraft for DC-4 and DC-6 landing gear, this ground lock may be readily installed or removed with one hand, or without removal of gloves during cold weather.

Of wedge-block type, unit has steel strap of sufficient length to pass over first cross-member of lower drag link. And steel spring clip, riveted to strap, affords easy snap engagement with cross-member. Lock is thus securely held in place, requiring no bolts or pins. Steel tab prevents damage to clip from improper handling of device.

Modified Motor-Generator Set Steps Up Electrical Checking

■ This re-wired GE motor generator set has proved a valuable aid in checking of electrical installations on PAA's Lockheed Constellations and Douglas DC-4s at La Guardia Field base. Airline's Henry Breitmeyer conceived advantages of the modification to facilitate servicing.

Unit permits checking of aircraft generator circuits and other electrical circuits during service periods, without necessity of engine run-up. Previously, electricians were required to wait approximately 8 hr., for completion of maintenance before commencing run-up for testing.

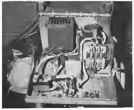
Device may also be employed to set craft's voltage regulators and reverse current relays before run-up. And battery carts can be charged in 4 hr. with the unit, whereas approximately 8 hr. were formerly required.

Mounted externally on the housing are three sets of plugs—top set for checking aircraft generator circuits, bottom two sets for supplying power to craft or to battery cart for charging. Using both lower plug sets, two craft may be supplied with power simultaneously. Protector caps for plugs prevent possibility of accidental shorting between terminals. Three-phase lights on housing face indicate whether power is on or off.

Mounted on dolly, unit may be spotted conveniently inside or outside hangars.

To simplify servicing of device, top is hinged to swing up and back, and front section is hinged to swing downward. With this arrangement, ready accessibility is afforded to various parts.

Use of device is estimated as saving approximately $9,000 annually.



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Recent Books

THE FLYING NORTH, by Jean Potter. The Macmillan Co, New York City Illustrated 261 pages. $3.75.

During World War II aviation in Alaska changed almost beyond recognition. The days of the pioneering and of adventurous flying souls in the sparsely settled areas of the northernmost possession ended when the Japs struck. In support of military operations and lend-lease ferrying to Russia, the CAA built up a vast system of modern airports and radio facilities rivaling those in the U. S. The work of the bush pilot, however, still continues for few of the Far North's settlements are served by new airways. Main theme of Miss Potter's book is the collection of many authentic, yet fantastic tales of heroism and aviation pioneering in the early days. Without such air pioneering, Alaska might still be the uncharted provincial north.

DICTIONARY OF FOREIGN TRADE, by Frank Henius. Prentice Hall, New York City. 1,018 pages. $2.50

The new revision of this dictionary first published in Jan. 1946 has been entirely rewritten and expanded to meet the needs of all persons engaged in foreign trade and the various aspects of import and export industries. Covering the subject in the widest sense, the book discusses buying, selling, packing, shipping, banking, invoicing, customs, insurance, and such other activities as are associated with the organization, management, and operation of international trade. There are more than 6,000 alphabetically entered definitions, as well as 3,000 abbreviations of foreign trade terms in English, French, Spanish, and German, plus reproductions of 300 foreign trade forms.

YOU CAN LEARN TO FLY, by Beverly E. Howard and William D. Strohmeier. Prentice Hall, New York City. Illustrated $3.75.

The authors, with about 11,000 hr between them, have turned out a neat book on how to do it. Since it is written in simple straightforward style and illustrated profusely throughout, novice airmen will find every subject interestingly covered—entertaining, too. George B. Post has contributed an appendix which considers flying with floats.

RADAR ENGINEERING, by Donald G. Fink. McGraw Hill Book Co., New York City. Illustrated 644 pages. $7.00.

Designed specifically to acquaint engineers and technicians in the fields of electronics and radio with the new methods and special applications of established techniques used in radio detecting and ranging of objects, the book is divided in two parts which may be considered respectively as theory and practice. Fundamental concepts essential to understanding radar technology are thoroughly covered in the first part. Second part is devoted to components and structures, also circuits used in various types of radar equipment.

INDUSTRIAL DIRECTORY OF MEXICO 1947-48 EDITION. Publicaciones Relland, S. de R. L., Plaza de la Republica No. 6—407, Mexico, D. F. 1,024 pages. $20.00

This directory includes a list of all Mexican industrial companies, their addresses, names of key personnel, types of raw materials used by manufacturers, products made and capitalization, plus the number of workers employed in each industry. So that U. S. buyers can use this directory, a special Spanish English dictionary is included which covers most of the words in the publication. Aviation trades people engaged in or planning exports to Mexico should find this work of practical value.

SERVOMECHANISM FUNDAMENTALS, by Henri Lauer, Robert Lesnick and Leslie E. Matson. McGraw-Hill Book Co., New York City. Illustrated, 277 pages. $3.50

Both engineering students and practicing engineers will find this a valuable basic treatment of servomechanics from the theoretical through the principles governing the operation of servocontrol devices. Working formulas, curves, practical examples and problems similar to those encountered in the field are provided.

RUSSIAN-ENGLISH CHEMICAL AND TECHNICAL DICTIONARY, by Ludmilla I. Callaham, John Wiley & Sons, Inc. New York City. 794 pages. $10.00.

With increasing frequency scientists, technologists and research workers are finding it necessary to refer to material published originally in the Russian language. This well-organized dictionary consists of some 80,000 technical terms in wide range of industries and professions as well as all types of general words likely to appear in technical articles.

DESIGN FOR FLIGHT, by Charles Hampson Grant, Greenberg Publisher, New York City. Illustrated 275 pages. $3.95

Beginners as well as the more advanced model plane enthusiasts will find Mr. Grant's second book on model aviation an interesting project. It is primarily written for the fan who would like to build and fly a model plane of his own creation. Theory and fundamentals are presented clearly. A large section is devoted to full-size plans and scale drawings, along with instructions on building and designing models powered by rubber strands or miniature gasoline engines.

COMPREHENSIVE STUDY RELATING TO AERONAUTICAL FACILITIES FOR METROPOLITAN AREA OF CHICAGO PROJECTED TO 1970. General Airport Co., Stamford, Conn. Illustrated, 239 pages.

This volume represents a report by the General Airport Co. which made a detailed study and analysis of aviation facilities for the Chicago metropolitan area, with gages of facilities to 1958 and 1970. Included among the principal items in this exhaustive study for the Illinois Bureau of Aeronautics are: A report on physical conditions which might effect aviation activities; economic and sociological factors which might be reflected in aero developments; a study of zoning laws, regulations and ordinances; ground transportation considerations influencing airport development; a study of safety factors; investigation of federally-owned, controlled, or operated airports within Chicago area; and a summary of technical developments and future trends bound to effect both aircraft and airport design and construction. Also presented is an estimate of overall costs covering the recommendations set forth in the master plan. The work offers special reference values to those ranging air developments in other urban centers.

Special Publications

A new book, similar to used-car appraisal guides issued in the Automotive industry, is now available to the aircraft industry for guidance to those engaged in buying, selling, financing, and insuring aircraft. It gives essential identification data, horsepower ratings, seating capacity, original factory prices and average appraisal variations. Accessories are listed and appraised separately. Publisher is National Market Reports, Inc., 1016 S. Michigan Ave., Chicago 5, Ill. Annual subscription is $7.80. "Employment Opportunities in Aviation Occupations" is a new pamphlet turned out by the U. S. Dept. of Labor with approval of the airlines. Detailed are the duties, qualifications, earnings, and working conditions of the various types of personnel employed by the aviation industry. It is being distributed by Supt. of Documents, Washington 25, D. C., for 20¢. "You Are a Partner With Air Transport" is title of a booklet incorporating address delivered by C. Bedell Monro, pres. of Capital Airlines, at NAA dinner honoring the 20th anniversary of the founding of Capital Airlines (PCA).

PATENT
LISTINGS

Following are selected listings of some of the more interesting patents on aviation developments granted through the U. S. Patent Office. Printed copies of any of these patents are obtainable directly from U. S. Patent Office, Washington, D. C. at a cost of 25¢ each.

Avigational Calculator, 2,418,925, pat. Apr 15, '47, E. Hill

Lubricating Oil Cell, 2,418,616, pat. Apr 15, '47, R. B. Grey and J. C. De Weese, assignors to Glenn L. Martin Co.

Gyroscope Control, 2,418,688, pat. Apr 15, '47, F. Fischer, vested in Attorney General of U. S.

Cowl Fastener, 2,418,108, pat. Apr 15, '47, W. H. Barlow, assignor to Scovill Mfg. Co.

Hydraulic Relief Valve, 2,418,145, pat. Apr 15, '47, O. A. Kehle, assignor to Adel Precision Products Corp.

Control Surface Design, 2,419,181, pat. Apr 15, '47, H. L. Pitt.

Heater Mixture Control, 2,418,896, pat. Apr 8, '47, A. A. Arnhym, assignor to Solar Aircraft Co.

Aircraft Brake, 2,418,868, pat. Apr 8, '47, R. A. Goepfrich, assignor to Bendix Aviation Corp.

Valve Stem Design, 2,418,874, pat. Apr 8, '47, E. C. Steiner, assignor to Wright Aeronautical Corp.

Propeller De-Icer, 2,418,889, pat. Apr 15, '47, L. A. Williams and H. J. De N. McCollum, assignors to Stewart-Warner Corp.

Aircraft Launcher, 2,418,708, pat. Apr 8, '47, R. C. du Pont, assignor to All American Aviation, Inc.

Inflatable Crash-Landing Device, 2,418,798, pat. Apr 8, '47, A. Whitmer, assignor to A. G. Evans.

Heat Exchanger, 2,418,191, pat. Apr 1, '47, W. C. Parrish, assignor to Stewart-Warner Corp.

Anti-Icing Apparatus, 2,418,200, pat. Apr 1, '47, M. L. Taylor, assignor to B. F. Goodrich Co.

Wing Flap Design, 2,418,278, pat. Apr 1, '47, W. H. Moore.

Controllable Wing Tip, 2,418,301, pat. Apr 1, '47, L. C. Heal, assignor to Miles Aircraft Ltd.

Landing Gear, 2,418,355, pat. Apr 1, '47, J. B. Wassall and W. N. Wallace, assignor to Lockheed Aircraft Corp.

Helicopter Controls, 2,418,407, pat. Apr 1, '47, R. R. Hays.

Variable Pitch Propeller, 2,417,617, pat. Mar 18, '47, W. E. Everts, assignor to Everel Propeller Corp.

Helicopter Pitch Control, 2,418,030, pat. Mar 25, '47, H. Hirsch, assignor to Curtiss-Wright Corp.

Engine Warming Apparatus, 2,418,082, pat. Mar 25, '47, A. W. Ruff, assignor to York Shipley, Inc.

Electrical Terminal Connection, 2,417,716, pat. Mar 18, '47, G. A. Tinnerman, assignor to Tinnerman Products, Inc.

Aviation People

E. R. Peterka (photo), mgr of aviation parts dept and director of sales promotion and advertising for Lamson & Sessions Co., has been awarded Legion of Merit for contribution to construction of high octane gasoline plants and redistribution of surplus property and materials During war he served as Lt Col and chief of materials distribution branch and property disposal staff of Air Materiel Command at Wright Field He is v-p of Aviation Distributors & Manufacturers Assn

L. T. Cohu E. R. Peterka

LaMotte T. Cohu (photo) has been elected pres of TWA, succeeding **Jack Frye**, who resigned. Formerly, Mr Cohu was chairman of board and gen mgr of Northrop Aircraft A member of TWA's board since '33, he has also served as pres of Aviation Corp, American Airways, and American Aircraft & Engine Co **Warren Lee Pierson**, pres of American Cable and Radio Corp, has been elected chairman of board and managing director of TWA's International div

William D. Strohmeier, recently v-p. of Chas H Gale Associates, has formed his own pub rel and sales promotion firm of Strohmeier Associates Prior to war, he was sales promotion mgr, for Piper Aircraft.

Karl J. Fairbanks has been appointed gen mgr of Sharman Fairchild & Associates

Ernest Rossiter, Jr, has been appointed director of cargo research for Canadian Pacific Air Lines.

Robert R. Scholl has been appointed North American's pub rel representative in N. Y.

Charles W. Deeds (photo) has been elected to board of directors of Fairchild Engine & Airplane Corp. A former director of Pratt & Whitney and United Aircraft, he is a member of IAS, SAE, and Quiet Birdmen.

G. B. Shaw C. W. Deeds

George B. Shaw (photo) has been named director of commercial sales for Glenn L Martin, succeeding **P. M.**

Magruder, who resigned Previously, Mr Shaw was an executive with General Motors. During war, he served with AAF as a member of Eastern district price adjustment board, and he was awarded Emblem for Exceptional Civilian Service by War Dept **Morgan R. Schermerhorn, Jr.**, (photo) has been elected a v.-p. of Glenn L Martin, where he has been controller

C E Deardarff (photo) has been appointed chief hydraulic engr of Pacific div of Bendix Aviation Corp Previously, he was landing gear and hydraulic group engr. with Douglas. **R. G Peterson** has been named eastern representative for Bendix

M R Schermerharn

C E Deardarff

Following have been elected directors of Douglas **Neil Petree, Frederick E. Hines**, and **Edward H McLaughlin.**

Peter Tarnqvist has been appointed West Coast representative for Scandinavian Airlines System

Jess B Bennett has been named asst to pres of Braniff

H F. Jahnson has joined California Eastern Airways as controller and treas

Lt. Col Thomas J. Cummings has been named officer-in-charge of AAF contracts at C-W

Joseph S Fessio has been appointed sales mgr for PAA's Pacific-Alaska div , and **Jasper N. Barnette, Jr.**, has been named supt of schedules for Latin American div.

Edwin M Fitch, formerly director of personnel relations for ATA has opened an industrial relations consulting firm, with Washington hq

E. W. Britton has been appointed service mgr of Wright Aero, with **H G Prall** as quality mgr

Mario Fontana of Fontana School of Aeronautics, has been elected to board of directors of reconstituted **Taylorcraft** company

Dean J. Hanscom has been appointed Western traffic mgr for NWA

Russell H. Frary has been appointed northwest representative for Minneapolis-Honeywell Regulator Co.'s aeronautical div.

NEA appointments **Wheaton W. Mies** has been named supt. of engineering, **William R Burns** has been appointed supt of maintenance and overhaul and **Robert H. Herrnstein** has been made director of economic development and budgetary control.

Robert L. Mussen has been named Convair's San Diego div. mgr., and **Mark R. Miller** has been appointed commercial sales mgr. with N. Y. hq.

John B Doriss has resigned as director of advertising for TACA Airways system

D Roy Shoults, v-p in charge of engineering for Bell, has been elected national chairman of aircraft technical committee of AIA.

Kenneth N Patrick, former director of industrial engineering at Kellett, has been appointed gen. mgr. of Bob White Organization

G. H. MaComber has been appointed gen traffic and sales mgr of LAMSA, UAL's Mexican subsidiary.

Hal A. Grayson has joined MCA as director of pub. rel

★ COMING UP ★

June 1—7: Aviation Writers Assn. Annual Convention Los Angeles

June 1—6 SAE Summer Meeting, French Lick Springs Hotel, French Lick Ind.

June 2 AIA Export Committee Meeting Los Angeles

June 2—4: NAA Annual Meeting Ft. Worth, Tex.

June 3—4 AIA Personal Aircraft Council Meeting, Los Angeles

June 4—6 Fifth Annual Airport Management Conference, A & M College of Texas College Station

June 4—6 Aero Medical Assn. 18th Annual Meeting, Hotel Ritz Carlton Atlantic City

June 7—8 13th Annual National Air Carnival Sponsored by Birmingham Aero Club Birmingham, Ala

June 9—10 Annual Meeting Aeronautical Training Society Mayflower Hotel Washington D C

June 17 ICAO South American Regional Air Traffic Control Meeting, Lima, Peru

June 30—July 1 Aviation Distributors & Manufacturers Assn Mid-Year Directors and Committee Chairmen's Meeting Mackinac Island, Mich

July 3—6: International Air Races, Long Beach Cal., sponsored by Chamber of Commerce

July 4—20 14th Annual National Soaring Meet Wichita Falls Tex

July 4—20 First Southwestern Aircraft Show Wichita Falls, Tex.

July 15 ICAO South Atlantic Regional Air Traffic Control Meeting Rio de Janeiro

July 16 State Aviation Forum (CAA-sponsored), Columbia S C

Aug 7—8 IAS Annual Summer Meeting, Los Angeles Cal.

Aug 7—9: National Flying Farmers Assn 1947 Convention, Oklahoma A&M College, Stillwater

Aug 19 ICAO Airdromes & Ground Aids Div Meeting Montreal

Aug 21—22 SAE West Coast Transportation & Maintenance Meeting, Biltmore Hotel Los Angeles.

Aug 30—Sept 1 1947 National Air Races. Cleveland Ohio

Sept. 1—21: IATA Technical Conference, Nice, France.

Sept. 15-17: First Annual Convention of Air Force Assn., Columbus, Ohio

Sept. 47 ICAO Southeast Asia Regional Air Navigation Meeting (India)

Oct. 2—4 SAE Autumn Aero Meeting Biltmore Hotel Los Angeles.

Oct 24—26 Air Day in Texas Harlingen

Nov 1—9 National Aircraft Show sponsored by AIA Navy Pier Chicago

Nov 4—7 Nation Airport Show & Institute Municipal Auditorium sponsored by Air Foundation and National Aeronautics Assn Cleveland

Dec 1—3 SAE Air Transport Meeting Hotel Continental, Kansas City Mo.

New Construction
AIRPORTS & AIRBASES

PROPOSED WORK

Joplin, Mo.—AIRPORT—City c/o G. A. Spiva, chn., Joplin Airport Bldg., 1011 Crest Dr., municipal airport imprvs. incl. administration bldg., new ramps and ramp enlargements, taxi strips along NE-SW and NS runways, addnl hangar and shop facilities, and paving on NW-SE runway $400,000. Pate Eng. Co., 801 Richard Bldg., Tulsa, Okla., consult. engr.

St. Louis, Mo.—AIRPORT IMPRVS.—City, c/o M. M. Kinney, pres. Bd. P. Service, 304 City Hall Zone 3, relocating all pipelines and telephone lines in connection with Lambert-St. Louis Municipal Airport expansion, $607,000; relocating grading, paving Brown Rd. to point 1 mi. east of present position with Lambert-St. Louis Municipal Airport expansion, St. Louis Co. $763,700.

Defiance, Ohio — AIRPORT — Bryan Rd. Trustees, Defiance Airport, Robert C. Zeller pres. airport, B. W. Petrie, Benton Harbor, Mich., consult. engr.

Lakehurst, N. J. — HANGARS — Yards & Docks Annex, Navy Dept., Arlington, Va. Lighter-than-air hangars alterations, NOY 14790, $115,000.

Mission, Tex. — AIRPORT — Central Valley Airport, c/o John Jones, Mission, airport constr. imprvs. $225,000.

Willow Run, Mich. — AIRPORT — Airline Terminal Corp., Willow Run airport addns., alterations. $370,000.

Winona, Minn. — AIRPORT — City, R. G. Wildegrebe, clk., voted $180,000 bonds imprv. municipal airport.

Ottawa, Ont.—RUNWAYS—Dominion Govt., Ottawa, extending runways at Uplands Airport for 4,000 ft. to 5,400 ft. $800,000. Dept. Transport, Ottawa, engr.

Puerto Cortes, Honduras—Harry J. Messer & Assoc., Alice, Tex., U. S. A., plans airfield. $150,000.

Buenos Aires, Argentina—Republic of Argentina, Buenos Aires, plans building for Air Ministry. About $4,000,000. Dept. P. Wks., Buenos Aires, engr.

Mexico—Jose F. Murguerza & Assoc., Monterrey, plans commercial airfields, Aguas Calientes $160,000; San Luis Potosi $125,000; Torreon, $200,000; Durango, $100,000; Saltillo, $200,000; Monclava, $10,000; Parras $30,000; Rosario, $70,000; Chihuahua $180,000; Fesiamo, $70,000; Merida, $170,000; Mazatlan, $210,000; Guadalajara, $290,000; Puerto, $290,000; Tabasco, $100,000; Oaxaca, $200,000; Queretaro, $100,000; Guanajuato $200,000; Tenasopo, $120,000; Panchuca, $100,000; Uruapan, $70,000; Acapulco, $70,000; San Geronimo, $57,000; Oriental, $40,000; Tierra Blanca, $80,000; Santa Lucrecia, $80,000; Chilpaccium, $50,000; Sabinas, $60,000; Victoria, $80,000; Saline Cruz, $60,000; Sombrerete, $50,000; Hermosillo, $80,000; Sierra Majada, $80,000.

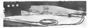
What's New

(Continued from page 17)

assembly rotates through 180 deg. Two limiting heads are used to indicate cam contour. Each head has floating gaging point and fixed pickup point. When piston is mounted on floating pressure shoe arbor through piston pin hole with piston skirt up, arbor is pushed into position and locked. Fixed pickup points contact bottom piston ring land ground to true circle. Floating gaging points rest on bottom of cylinder skirt. As piston is rotated through 90 deg. either side of center, meters indicate variation in cam contour between ring land and skirt.

Black Light Borescope.............78

Development of 100w. black light, one-third size of cigarette, allows



sensitive inspection methods in formerly inaccessible locations, when used with

specially designed borescope made by **Magnaflux Corp.**, Chicago. More reliable methods than usual visual inspection of inner surfaces of aircraft propellers has required small size black light source of high intensity to take advantage of sensitivity available with Zyglo penetrant to inspect non-magnetic braze and weld joints. To use new instrument inside surface is processed with Zyglo or Magnaglo materials as required. Inspection takes place by viewing fluorescent indications of defects through borescope carrying black light at viewing head. White light is also available at head to aid visual checking of location and appearance of defects.

Aircraft Magneto Test Machine.....19

Self-contained and powered by 3 hp variable speed hydraulic drive aircraft magneto test machine Model MG-1, was designed by **Greer Hydraulics, Inc.**, Brooklyn, N. Y., to meet test requirements of Scintilla low-tension magnetos. Two sparkgap banks are pro-

vided with 18 adjustable gaps and 18 coils for each bank. Mounting pad is provided for one magneto and two distributors. Features of this unit include sufficient power to test latest type low-tension magnetos; variable stepless speed changes throughout full range of operation; and fluid drive to eliminate rpm drop when load is applied.

Modulation Meter 20

Using no batteries or tubes and having frequency range of 300 kc to 300 mc., new modulation meter has been developed by **Gables Engineering**, Coral Gables, Fla., for private or commercial aircraft to facilitate checks on HF and VHF transmitter operation. Designated as Model G-232, it indicates percentage of modulation and serves as relative check on RF field strength. It can use link or capacity coupling and has push type terminals for pickup connections. Only adjustment is front panel knob for adjusting RF input. To operate, meter leads are placed in field and carrier level is set to mark on meter. Switch is thrown to read meter. Additional switch is provided for checking either positive or negative peaks. Weight is 1 lb.

Direction-indicator Potentiometer...21

Ohmite Mfg. Co., Chicago, has developed Model RB-2 direction-indicator potentiometer to provide low cost method of indicating position of rotary-beam antenna, wind vane, or

other rotating device. For use with rotary-beam antenna, shaft of unit is coupled to rotate with antenna. Potentiometer is then connected to 6v battery and 0-1, 0-1.5, or 0-2 milliamp d c meter with specially marked scale. Milliameter will indicate position of antenna. If desired, 6v a c source can be used with d c meter incorporating dry disc rectifier.

Aircraft Fire Extinguisher........ 22

Developed for use in aircraft interiors on fires originating in carbonaceous materials (seat cushions, blankets, papers, etc.), new water solution type fire extinguisher is made by **Walter Kidde**

& Co., Belleville, N. J. Unit contains 1½ qt of antifreeze water solution, weighs 7 lb when filled, and is powered with small life-vest type cartridge of carbon dioxide. Other than cartridge device requires no special tools, measuring devices, or materials, is said to produce no toxic fumes and can be recharged with water in flight.

Fatigue Machine 23

Embodying many principles of Sonntag Universal Fatigue Machine, particularly automatic maintenance of constant load throughout period of load test, new Sonntag Fatigue Machine Model SF-4 announced by **Baldwin Locomotive Works,** Philadelphia is equipped for tension-compression testing both at ambient and high temperatures. Since no recalibration is needed during test supervision is reduced to a minimum. Dynamic load is applied by revolving eccentrically disposed mass. Eccentric is of micrometer screw type, permitting fine hand-adjustments, amount of eccentricity being read like micrometer, with graduations in pounds. Entire working mechanism is seismically suspended on soft tension springs said to absorb over 99% of vibratory forces. Dynamic load is claimed to remain constant and overall variations to be less than ± 2%. Maximum capacity in either direction is 10,000 lb. Static preload capacity is 0 to 5,000 lb; alternating (dynamic) load capacity ±5,000 lb.; speed of testing, 3,600 load cycles per min., and maximum movement of reciprocating platen, ± 1/16 in. Weight is 3,000 lb and overall dimensions 43 × 43 × 75 in.

Broaching Machine 24

American Broach & Machine Co., Ann Arbor, Mich., announces changes in design of vertical hydraulic Type T-3-way broaching machine. Changes have been made in coolant assembly and minor changes have been made in work table. Coolant is supplied from enlarged reservoir located in work table base by integral motor and centrifugal pump unit located on side of machine below operating lever. Mounting is such that pumping unit can be taken out by removal of four screws and disconnecting inlet and discharge pipes. Inlet pipe is provided with screen to prevent large chips from passing through pump. Coolant discharge pipe extends 3 in. above work table with shut-off valve located at table height. Control of coolant pump motor is through start-and-stop-button station. Machine is made in 4,5, and 8-ton sizes with 24-in. stroke and in 6, 10, and 15-ton sizes with 35-in. stroke. It is adaptable to push, pull, and surface broaching operations and can be used for arbor, straightening and assembly work.

Reflex Oscillator Tube 25

Philips Laboratories, New York City, announces development of new reflex oscillator for very short waves, called "Multi-Reflection Tube" designed to have higher efficiency than previous models. In this tube electrons execute a pendulum motion about modulator system with a constant periodic time. Each time they pass modulator system they induce a current of correct phase. Constancy of periodic time is achieved by a suitable choice of potential gradient between modulator system and repeller electrode and cathode, respectively. Tube is described as having an effective power of 15 to 20w at a wave length of 12 cm. It is stated to be suitable for either continuous or pulsating operation.

Information Tips

Check Valves 26

General description, pressure drop charts and engineering data on swing check valves and cone check valves are presented in Bulletins A42 and A53 respectively, published by **Parker Appliance Co.,** Cleveland, Ohio.

Valve Gear Design............ 27

Information is available from **Wilcox-Rich Div., Eaton Mfg. Co.,** Detroit, on new comprehensive book covering field of valve gear design including, cams, tappets, valve springs, and related units for all types of internal combustion engines.

Yield Strength Calculator......... 28

Giving tables and instructions for yield strength determination of aluminum alloys, brass, copper, and carbon and low alloy steels, new slide rule type calculator (price $1.00) is announced by **Aluminum Research Institute,** Chicago.

Metal Finishing Data 29

Divine Brothers Co., Utica, N. Y., announce two new bulletins covering metal finishing. First defines buffing and polishing operations, also gives table for estimating surface fpm from rpm for 4- to 24-in. dia. wheels. Second bulletin describes wheel balancing, tabes available and eight types of wheel hubs.

Solderless Wiring 30

Covering line of solderless wiring devices, new selection data book with handy reference tabs on pages is published by **Aircraft-Marine Products, Inc.,** Harrisburg, Pa. Included is graphic selector chart and actual samples of terminals.

Aluminum Finishes 31

Offered in two volumes, "Finishes for Aluminum" is published by **Reynolds Metals Co.,** Louisville, Ky. One volume is devoted to cleaning treatments, mechanical surface finishes, chemical surface finishes, electrolytic oxide treatments, elec-

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troplated coatings, paint coatings, and ceramic coatings. Other includes information on materials, equipment, solution preparation and procedure and control of various finishes. Price is $2 00

Tracer 32

Intended for use with Profilometer new tracer made by **Physicists Research Co.**, Ann Arbor Mich known as Type LA is for measuring surface roughness in bores as small as ⅜ in i d at various depths to 38 in or greater on hydraulic cylinders, camshafts and tubing.

Lathe 33

Catalog 18 F from **South Bend Lathe Works,** South Bend, Ind., describes 13-in swing quick change gear and toolroom lathes for cutting 48 pitches of screw threads, right or left hand and having 48 power longitudinal feeds and crossfeeds

Hole Punching Units 34

Containing specifications and standard punch and die sizes new catalog from **Wales Strippit Corp.** North Tonawanda N. Y., describes line of hole punching units and their mounting methods

Drill Head 35

Folder from **Industro-Matic Corp. of America,** New York City, describes "Hydromat", new drill head for drilling holes from No 88 drill to 3 in, and boring up to 8 in. dia., featuring variable air hydraulic feed

Drilling Machines 36

Sibley Machine & Foundry Co., South Bend Ind offer new folder describing 24- and 28-in drilling machines and accessories

Wiper Rings 37

Wyco Laboratories Inc., Dayton, Ohio announce resumption of manufacture of AN-6231 hydraulic cylinder wiper rings.

Connectors 38

"Cannon Plugs for Electric Circuits of Industry" new book published by **Cannon Electric Development Co.** Los Angeles is digest of ideas adaptable to aviation industry for assembly, servicing, maintenance and portability of electric equipment through use of connectors.

Radio and Electronic Products 39

With special emphasis on equipment for industrial maintenance, research and production requirements new 164 page catalog issued by **Allied Radio Corp.**, Chicago covers over 10,000 radio and electronic products, indexed for ready reference.

Relays 40

Catalog 10-A issued by **Guardian Electric Mfg. Co.**, Chicago describes line of relays and contains charts giving operating and contact data text matter on suggested applications and contact and mounting instructions for each relay

Solenoid 41

Consisting of but five components (base, armature coil coil locks, and back stops), new type solenoid is described in circular from **Practical Electric Co.**, Melvindale, Mich., which also contains dimension and rating specifications.

Floor Boxes 42

Russell & Stoll Co., New York City, has issued new catalog covering line of watertight floor boxes and receptacles, combination floor extension sets, floor outlet type receptacles, heavy duty floor receptacles, and plugs.

Capacitors 43

Bulletin 262 issued by **Sprague Electric Co.**, North Adams Mass describes line of "Midget Paper Dielectric Capacitors" designated as 65P and 69P and which are said to operate at 85 deg C and have humidity protection for normal radio and other uses.

Electronic Controls 44

Containing specifications descriptions, and diagrams, Bulletin Z-8408 from **Wheelco Instruments Co.**, Chicago covers line of electronic controls including measuring systems, multronic, proportioning and automatic positioning control millivoltmeter, potentiometer, and resistance

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thermometer controllers, indicating pyrometers, resistance thermometers, portable potentiometers and pyrometers input controllers, and selector switches.

Electronic Tube Manual 45

Discussing electronic receiving tube applications and performances, and containing performance curves ratings outline drawings basing diagrams and other data, new 700-page technical manual has been published by **General Electric Co.** Syracuse, N. Y. Selling for $5.00, it carries revision service through 1948, with further service available at $1.00 per year

Wiring Assembly Parts 46

Separate bulletins from **Winchester Co.**, New York City describe (1) line of small stand-off terminals, (2) mounting controls for high voltage circuits in radio transmitters, television receivers, and power supplies, and (3) 4-contact miniature connectors designed for applications where space is limited such as in aircraft equipment

Plates for Machining 47

Literature from **Joseph T. Ryerson & Co.**, Chicago, explains machining advantages of "E-Z Cut" steel plate developed for applications involving machining such as production of rubber molds, machine parts, die bases, and jigs and fixtures. Included are analysis and physical properties of material

Aircraft Accessories 48

Scott Aviation Corp., Lancaster, N. Y. announces new catalog of aircraft accessories including details on three new brake cylinders available for Seebee, Bellanca, Fleet and Commonwealth planes.

Airplane Tires 49

Featuring aircraft tires, tubes, and propellers new 40-page catalog published by **Firestone Aircraft Co.**, Akron Ohio, describes line of aircraft accessories including radios, batteries, finishes flight accessories steerable tail wheels, store display equipment, aviation books and advertising helps

Tube Connector Fittings 50

Catalog pages are available from **Everhot Products Co.**, Chicago, on "Everseal" tube connector fittings designed to prevent leakage in gas and oil lines, and reported to be capable of standing greater strain and pressure than tubing itself

Aerial Camera 51

Information is available from **Fairchild Camera and Instrument Corp.**, Jamaica, N. Y., on redesigned aerial camera K-20 weighing less than 10 lb. and adapted for standard 4 × 5-in. cut-film magazine, cut-film holder, and film pack.

Hose Fittings 52

Catalog section issued by **B. F. Goodrich Co.**, Akron, Ohio covers line of fittings for gasoline tank, distillate, fuel oil and aircraft refueling hose, giving size and weight specifications

Design Service 53

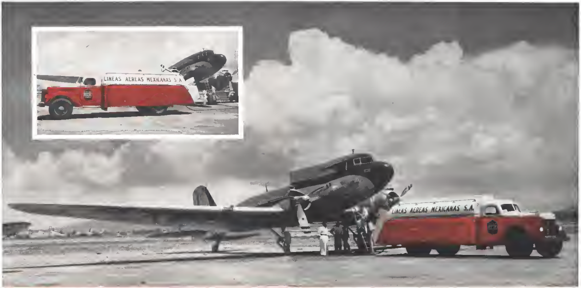
Containing case histories and pictorial information, new booklet from **Designers for Industry, Inc.**, Cleveland, Ohio describes integrated industrial and design services, including industrial design development engineering, experimental manufacturing production engineering management counsel, and market analysis.

Tool and Machine Catalog 54

New catalog published by **George Scherr Co.**, New York City, gives specifications and descriptions of line of tools machines and instruments, including laboratory equipment, gas and electric furnaces, machinist's tools, tool room specialties, machinist's optical equipment, transmissions, and variable speed drives

Obsolescence in Industry 55

Article in first issue (March) of "Press Proofs" new monthly published by **Hydraulic Press Mfg. Co.**, Mount Gilead Ohio, discusses vital difference between depreciation and obsolescence of machinery



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Jet Morphology

(Continued from page 50)

combinatory possibilities within the scheme described in the preceding.

It may be added here that in the future, when more will be known about rockets traveling in space, it might be convenient to introduce the freely available electromagnetic and corpuscular radiations as additional elements A_5 and A_6 into the fundamental matrix A.

Problems of Nomenclature

In the initial stages only a few jet engines were known. Each inventor or groups of inventors naturally assigned more or less arbitrary designations to their creations. This practice, if continued, is apt to lead to considerable confusion because of the great number of possible propulsive power plants, totality of which is so great that the problem of nomenclature assumes a character analogous to that of naming chemical molecules or chemical substances. Some agreement as to a systematic nomenclature clearly would seem to be in order. We therefore propose to make some simple suggestions with the view of submitting the issue, for final decision, to a national or international technically competent board.

First suggestion is to use four prefixes depending on whether the medium through or over which the device is propelled is the vacuum, air, water, or the earth. The four prefixes chosen might be "vacuo-", "aero-", "hydro-", and "terra-". These prefixes roughly also determine suitable classes of propellants and of chemical reactions to be used for activation and operation of the propulsive power plants in question.

Our second suggestion concerns the designation to be used for various types of motion of engine parts relative to the working fluid.

If there exists no initial relative motion between propellants or working fluid, we speak of a rocket proper. If motion is translatory we propose the designation "duct". Such ducts are generally also present in propulsive power plants using rotors (rotary parts) and pistons (oscillatory parts) for precompression of the working fluid. Since these rotary and oscillatory motions are characteristic of the devices involved, we propose to use the words "turbo-" and "piston" to designate them.

External thrust augmentation may be accomplished through the use of propellers, wheels, external trumpets, etc., while internal thrust augmentation need not be further characterized, since it is determined through numerical values of the propellant parameter β.

On the basis of the suggestions made, we arrive at the following types of designations for propulsive power plants using free air and free water as part of the working fluid:

Free Air Intake	Free Water Intake
aeroduct	hydroduct
aeroresonator	hydroresonator
aeropulse	hydropulse
aeroturbojet	hydroturbojet
aeroturbopropeller	hydroturbopropeller
aeropistonjet	hydropistonjet
aeropistonpropeller	hydropistonpropeller

The aeroresonator and the aeropulse are distinct, because one operates as a self-resonating engine while the other uses timed injection and ignition and reaction and is therefore more flexible.

Designations such as pulsejet, resojet, and so on, for the aeroresonator are ambiguous, since there are many types of pulse jets and resojets. These designations are consequently unsatisfactory, and we propose that they be abandoned in favor of the more consistent scheme proposed in the preceding.

Another equivocal designation currently in use for the aeroduct is the term ramjet. There are actually many ramjets—such as the aeroduct, the hydroduct, and others. These more specific terms should be used in preference to the name ramjet.

Description of the remaining matrices D, E, and F, should cause no special difficulties. Thus we may speak of an aeroduct activated by a self-igniting liquid fuel. Abbreviations for these propellant characteristics might, however, be used such as I = self igniting and L = liquid. (The Germans used the designation "Hypergol" in this case.) The above mentioned aeroduct might thus be called an IL-aeroduct.

Combinatory propulsive power plants also may be logically described by using combinations of the words which define the basic power plants involved. Thus the double ducted hydroturbojet might be called the hydroturbojet-hydroduct.

It is further suggested that standard diagrammatic representations of the various possible propulsive power plants be introduced for use in drawings. Thus the simple hydroturbojet and the combinatory double ducted hydroturbojet may be depicted as shown in Figs. 2 and 3.

It should be emphasized that the principle of systematic classification presented in this paper is most useful because the principle uncovers gaps in the array of existing power plants, and because it also gives suggestive directives for invention and construction of new engines.

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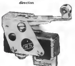

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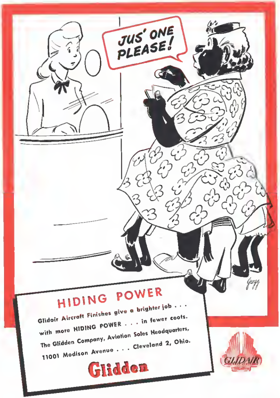

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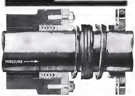

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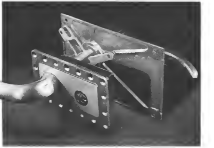

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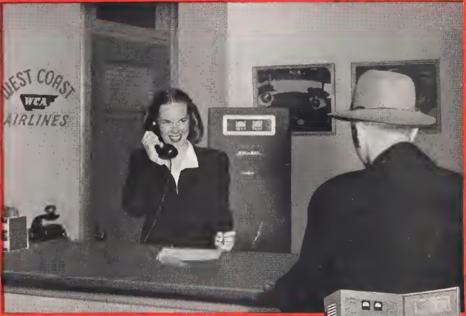

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